2 Mandatory Measures

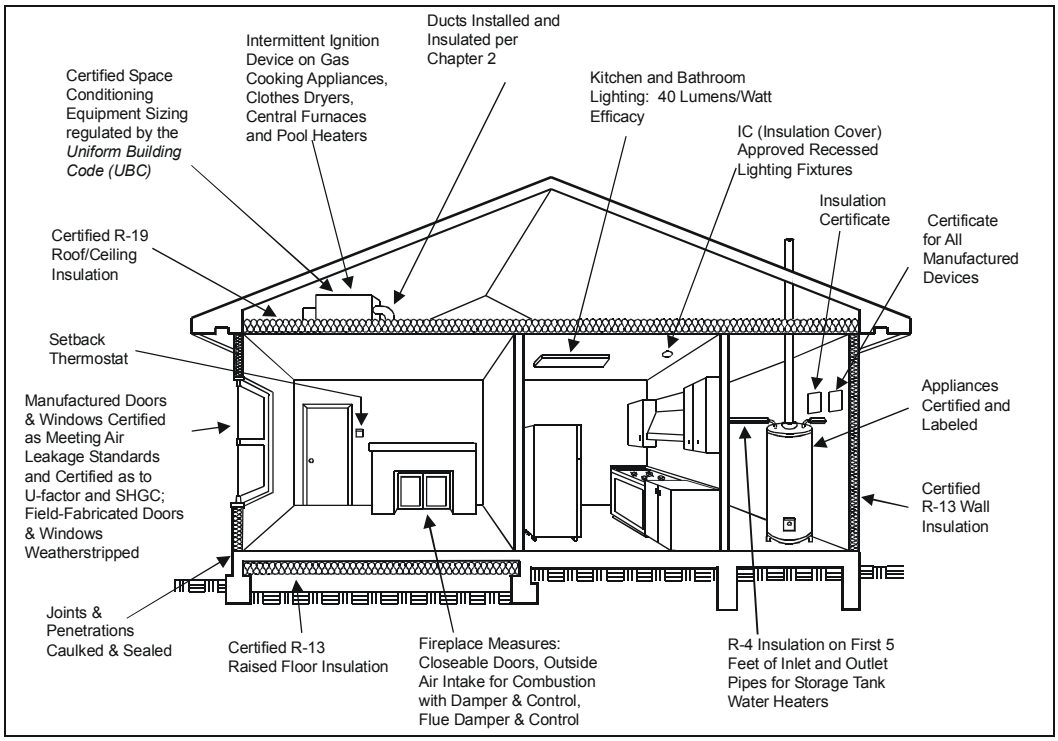
This chapter discusses the conservation features and devices mandated by the *Energy Efficiency Standards* (standards). These requirements apply with either the prescriptive or performance approaches to compliance. This chapter covers the following topics.

- Introduction
- Insulation
- Fenestration / Exterior Doors
- Infiltration and Moisture Control
- Space Conditioning
- Water Heating and Plumbing
- Lighting
- Compliance Documentation

2.1 Introduction

All new residential construction covered by the standards and explained in this *Manual* must meet or exceed certain minimum energy efficiency requirements, regardless of the compliance approach. These minimum requirements are referred to in the standards as ***mandatory measures.*** The mandatory measures address all aspects of energy efficient design and construction. The requirements are summarized in Figure 2-1. More detail is provided in the sections that follow.

Figure 2-1 – Summary of Mandatory Measures



The mandatory measures represent a minimum level of efficiency. To achieve compliance with other parts of the standards, higher levels of efficiency may be required.

2.2 Insulation

The R-value of insulation (or any material or building component) is the measure of its thermal resistance expressed in ft^2-hr-°F/Btu. This value may be obtained from Appendix B or from manufacturer's literature.

The rated R-value of mineral fiber (batt) insulation is based upon its fully expanded thickness. When the insulation is compressed, the R-value is reduced. The most common insulation compression occurs with R-19 and R-22 insulation batts installed in locations with a nominal 6 inch framing that is actually only 5.5 inches thick. To achieve its rated insulation value, an R-19 batt of insulation expands to a thickness of six and one quarter inches. If it is compressed into 2x6 framing with an actual depth of 5.5 inches, the insulation R-Value is lowered to R-17.8. See Table 2-1 for some common installed insulation values.

Table 2-1 – Installed R-Values for Mineral Fiber Batt Insulation[1]

Standard R-Value	Nominal Lumber Size	Actual Cavity Depth	Installed R-Value
13 (3.625")	2x4	3.5"	13
15 (3.5")	2x4	3.5	15
19 (6.25")	2x6	5.5"	17.8
21 (5.5")	2x6	5.5	21
22 (6.75")	2x6	5.5"	20
30 (9.5")[2]	2x10	9.25"	30
38 (12")[2]	2x12	11.25"	37

1. Based on manufacturer's data.

2. Note that batt insulation with these R-values is available in smaller thicknesses. R-30 may be achieved with an 8.25-inch to 8.5-inch batt, and R-38 may be achieved with a 10.25-inch to 10.5-inch batt. If this thinner insulation is used in the framing sizes listed here, the insulation would retain its full rated R-value because it would not be compressed.

The R-value of loose fill insulation depends on proper installation. See Section 2.2.3.

2.2.1 Certification of Insulating Material

Requirements

Insulating materials must be certified and labeled by the manufacturer. Urea formaldehyde foam insulation may only be installed in exterior walls with an interior vapor barrier. Insulating materials installed in exposed applications must have a flame spread of 25 or less and a smoke development rating of 450 or less.

§118

(a) Certification by Manufacturers. Any insulation of the type and form listed below may be installed only if the manufacturer has certified that the insulation complies with the California Code of Regulations, Title 24, Part 12, Chapter 12-13, Standards for Insulating Material.

Type	*Form*
Aluminum foil	*reflective foil*
Cellular glass	*board form*
Cellulose fiber	*loose fill and spray applied*
Mineral aggregate	*board form*
Mineral fiber	*blankets, board form, loose fill*
Perlite	*loose fill*
Phenolic	*board form*
Polystyrene	*board form, molded extruded*
Polyurethane	*board form and field applied*
Polyisocyanurate	*board form and field applied*
Urea formaldehyde	*foam field applied*
Vermiculite	*loose fill*

(b) Installation of Urea Formaldehyde Foam Insulation. Urea formaldehyde foam insulation may be applied or installed only if:

1. It is installed in exterior sidewalls; and

2. A four mil thick plastic polyethylene vapor barrier or equivalent plastic sheeting vapor barrier is installed between the urea formaldehyde foam insulation and the interior space in all applications.

(c) Flamespread rating. All insulating material shall be installed in compliance with the flamespread rating and smoke density requirements of Sections 2602 and 707 of the Title 24, Part 2.

The California Standards for Insulating Materials, which became effective on January 1, 1982, ensure that insulation sold or installed in the state performs according to the stated R-value and meets minimum quality, health and safety standards.

Manufacturers must certify that all insulating materials comply with California Standards for Insulating Materials. Builders may not install the types of insulating materials indicated in §118(a) unless the manufacturer has certified the product. Builders and enforcement agencies should use the Department of Consumer Affair's *Consumer Guide and Directory of Certified Insulation Material* to check compliance. Building departments receive a copy of the current directory. If an insulating product is not listed in the most recent edition of the directory, or to purchase a directory, contact the Department of Consumer Affairs Thermal Insulation Program at (916) 574-2065.

Note: Urea Formaldehyde is restricted by §1553 of Title 20. If such products are certified, this is verification that the restrictions of §1553 were met. The restrictions in §118 also apply.

California Standards for Insulating Materials also require that all exposed installations of faced mineral fiber and mineral aggregate insulations must use fire retardant facings. Exposed installations are those where the insulation facings do not touch a ceiling, wall or floor surface, and faced batts on the underside of roofs with an air space between the ceiling and facing. These installations require insulation that has been tested and certified not to exceed a flame spread of 25 and a smoke development rating of 450.

Flame spread ratings and smoke development ratings are shown on the insulation or packaging material or may be obtained from the manufacturer.

An Insulation Certificate (IC-1) signed by the insulation installer must be posted in a conspicuous location or made available with the building permit at the time of installation and inspections.

2.2.2 Ceiling Insulation

Requirement

Wood framed ceiling / roof construction assemblies must have at least R-19 insulation or a maximum U-factor of 0.051. Metal framed ceiling/roof constructions must have a U-factor of 0.051 or less. Some areas of the ceiling/roof can fail to meet the requirement as long as other areas exceed the requirement and the weighted average U-factor is 0.51 or less.

§150(a)

(a) Ceiling Insulation. The opaque portions of ceilings separating conditioned spaces from unconditioned spaces or ambient air shall meet the requirements of either 1 or 2 below:

1. Ceilings shall be insulated between wood framing members with insulation resulting in an installed thermal resistance of R-19 or greater for the insulation alone.

ALTERNATIVE to Section 150(a)1.: Insulation which is not penetrated by framing members may meet an R-value equivalent to installing R-19 insulation between wood framing members and accounting for the thermal effects of framing members.

2. The weighted average U-factor of ceilings shall not exceed the U-factor that would result from installing R-19 insulation between wood framing members in the entire ceiling and accounting for the effects of framing members.

R-19 is a mandatory *minimum* level of insulation in a wood frame assembly. This minimum level is typically superseded by the prescriptive requirements. The insulation may be of greater insulating value in certain areas of the ceiling and of lesser insulating value in other areas of the ceiling provided the overall weighted average U-factor does not exceed

the equivalent R-19 framed value (maximum U-factor less than or equal to 0.051) as documented on a Form 3R, explained in Appendix G, *Glossary*, *R-Value*.

Insulation not penetrated by framing, such as rigid insulation, can comply with the mandatory R-19 as long as the assembly U-factor is less than or equal to 0.051. The rigid insulation can actually have a rated R-value of less than R-19 and meet this requirement. Compliance can be documented with a Form 3R.

Metal or steel frame assemblies cannot use a Form 3R but have several options available. Use pre-calculated U-factors from Appendix G, pre-calculated metal frame assemblies from Appendix G, calculate the assembly U-factors using form ENV-3 for metal frame assemblies (see Appendix I), or use EZFRAME (see Appendix E) or another method based on the ASHRAE zonal method (1993 *ASHRAE Handbook of Fundamentals*).

Insulation must be certified in compliance with §118 (see Section 2.2.1). Ceiling insulation should extend far enough to the outside walls to cover the top plate. However, insulation should not block eave vents in attics because if the flow of air is blocked, water vapor may condense on the underside of the roof, reducing the insulation's effectiveness and possibly cause structural damage. (See Figure 2-2 and Figure 2-3.)

Where a roof slopes down, insulation may be tapered at the wall. An elevated truss or similar treatment is not needed for full insulation depth at the outside of the wall, but may be desirable. If insulation is tapered for more than three feet from the outside wall, this must be reflected in a weighted average U-factor calculation for the ceiling assembly.

Ceiling insulation levels should correspond to levels specified on the CF-1R and IC-1 (insulation certificate) forms. Although R-19 between wood framing is the minimum mandatory level for ceiling insulation between wood framing members, the package or performance requirement may establish a higher level. Check manufacturers' data (supplied by the builder) for compliance with the requirements of §118.

Fiberglass insulation levels are labeled on the insulation face and should be verified against the levels required by the CF-1R.

Clearances: Incandescent recessed fixtures must be approved for zero-clearance insulation cover (IC-rated). Alternatively, a box built over a recessed fixture so that the fixture is no longer recessed into the insulated ceiling and to provide clearance between the fixture and the insulation is acceptable. Insulation clearances from appliances should meet manufacturer specifications and local code restrictions.

Figure 2-2 – Ceiling Insulation Construction Detail

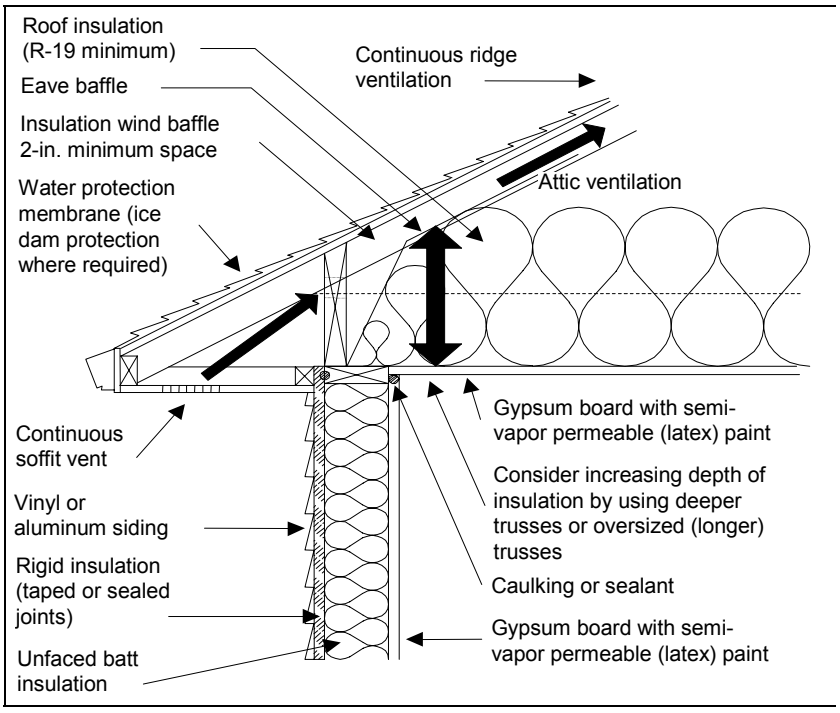
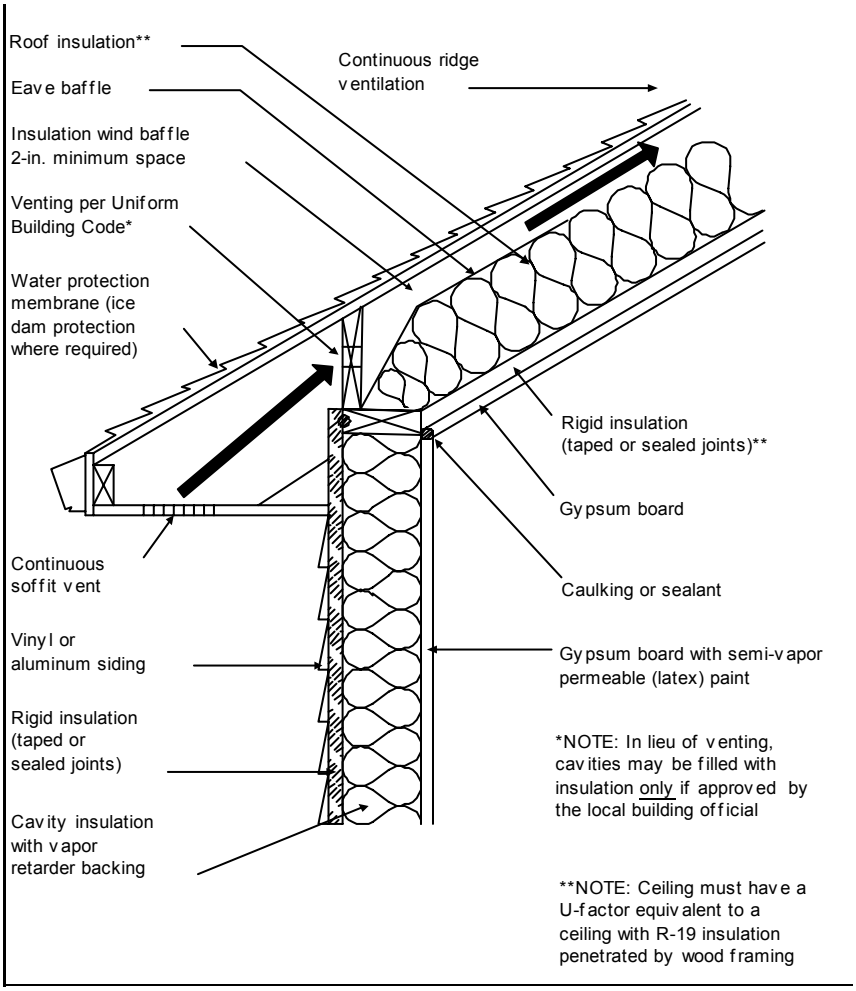


Figure 2-3 – Cathedral Ceiling



Where ceiling insulation is installed next to eave or soffit vents, a rigid baffle should be installed at the top plate to direct ventilation air up and over the ceiling insulation. The baffle should extend beyond the height of the ceiling insulation and should have sufficient clearance between the baffle and roof deck at the top (see Figure 2-2 and Figure 2-3).

Loose fill insulation must be blown in evenly and insulation levels must be verified. The insulation level can be verified by checking that the depth of insulation conforms to the manufacturer's coverage chart for achieving the required R-value. Additionally, three criteria the installer must consider are: 1) roof slope, 2) ceiling slope and 3) clearance. The installer should follow the guidelines shown in the construction portion for loose fill insulation (see 2.2.3).

Incandescent fixtures recessed into insulated ceilings must be approved for a zero-clearance insulation cover. Insulation clearances from appliances should meet manufacturer specifications and local code restrictions should be verified.

The Insulation Certificate (IC-1) must be completed and signed by the insulation contractor or general contractor. This form is either posted at the job site or made available during inspection and when completed, a copy of this form must be provided to the first occupant of the building.

Example 2-1 – Application of Mandatory Insulation Levels

Question

A computer method analysis shows that a new house requires R-30 ceiling insulation to comply using the performance approach, but the minimum mandatory insulation level for ceiling insulation is only R-19. Which insulation level should be used?

Answer

R-30. The higher insulation level must be installed for the building to comply.

Question

A small addition to an existing house appears to comply with only R-15 ceiling insulation using a performance approach. Does this insulation level comply with the standard?

Answer

No. R-15 would not be sufficient because the required minimum ceiling insulation level established by the mandatory measures is R-19.

2.2.3 Loose Fill Insulation

Requirement

When loose fill insulation is installed, it should be blown in evenly. The minimum installed weight per square foot and the minimum depth must conform to the insulation manufacturer's coverage chart for the listed R-value.

§150(b)

(b) ***Loose Fill Insulation.*** *When loose fill insulation is installed, the minimum installed weight per square foot shall conform with the insulation manufacturer's installed design weight per square foot at the manufacturer's labeled R-value.*

When installing loose fill insulation, the following guidelines should be followed:

1. For wood trusses that provide a flat ceiling and a sloped roof, the slope of the roof should be at about 4:12 or greater in order to provide adequate access for installing the insulation. Insulation thickness near the edge of the attic will be reduced with all standard trusses, but this is acceptable as long as the average thickness is adequate to meet the minimum insulation requirement.
2. If the ceiling is sloped (for instance with scissor trusses), loose fill insulation can be used as long as the slope of the ceiling is no more than 4:12. If the ceiling slope is

greater than 4:12 feet, loose fill insulation should not be used unless it incorporates non-water soluble adhesive binder.

3. At the apex of the truss, a clearance of at least 30 inches should be provided to facilitate installation and inspection.

When eave vents are installed, adequate baffling shall be installed at the soffit to deflect the incoming air above the surface of the insulation. Baffles shall be in place at the time of framing inspection.

Follow the above guidelines when inspecting loose fill insulation to ensure adequate coverage, baffling at eave vents and installation in accordance with manufacturer specifications.

2.2.4 Wall Insulation

Requirement

Wood framed walls must have a minimum of R-13 in the cavities between the studs or a maximum U-factor of 0.088. Metal-framed walls must have the equivalent thermal performance of a wood wall with R-13, which is a U-factor of 0.088. There is no minimum insulation requirement for mass walls.

§150(c)

(c) ***Wall Insulation.*** *The opaque portions of frame walls separating conditioned spaces from unconditioned spaces or ambient air shall meet the requirements of either 1 or 2 below:*

1. Wood framed walls shall be insulated between framing members with insulation having an installed thermal resistance of R-13 or greater. Framed foundation walls of heated basements or heated crawl spaces shall be insulated above the adjacent outside ground line with insulation having an installed thermal resistance of at least R-13.

ALTERNATIVE to Section 150(c)1: Insulation which is not penetrated by framing members may meet an R-value equivalent to installing R-13 insulation between wood framing members and accounting for the thermal effects of framing members.

2. The weighted average U-factor of walls shall not exceed the U-factor that would result from installing R-13 insulation between wood framing members and accounting for the effects of framing members.

Compliance for wood frame walls can be met by specifying at least R-13 insulation between framing members (the compliance approach may require a higher level). A U-factor can be determined by using standard values from Appendix I (no Form 3R is required when these values are used). Appendix H contains pre-calculated Form 3Rs for assemblies, including those with rigid insulation (a copy of the form may be submitted with compliance documentation). An assembly U-factor may also be calculated using a Form 3R.

Metal or steel frame assemblies cannot use a Form 3R but have several other options. Use pre-calculated values from Appendix G, pre-calculated metal frame assemblies from Appendix I, calculate the assembly U-factors using form ENV-3 for metal frame assemblies (see Appendix I), or use EZFRAME or another method based on the ASHRAE zonal method (1993 *ASHRAE Handbook of Fundamentals*).

Mass walls that have no framing, such as masonry or concrete exterior walls, do not have to meet the R-13 minumum insulation requirement (see Figure 2-4).

Framed foundation walls of heated basements or heated crawl spaces must be insulated above the adjacent outside ground line with at least R-13 insulation.

Insulation not penetrated by framing members, such as rigid insulation over the face of framing, may meet an R-value equivalent to a wall with R-13 insulation adjusted for the effects of wood framing 16" o. c. (maximum U-factor 0.088). Documenting equivalency for a wall assembly may also be shown on the Form-3R.

Insulation may be of greater insulating value in certain areas of the wall and of lesser insulating value in other areas of the wall provided that the overall weighted average U-factor does not exceed the equivalent R-13 framed value (maximum U-factor less than or equal to 0.088).

U-factors for concrete and masonry walls can be determined using the simplified masonry calculation method and Form 3R (see Appendix I).

Note: An existing structure, such as a garage, with R-11 framed walls that comply with performance approach, need not comply with the mandatory R-13 wall insulation. The addition must achieve compliance under an energy budget approach with R-11 insulation in these walls. See Chapter 7.

Figure 2-4 – Concrete Wall Insulation

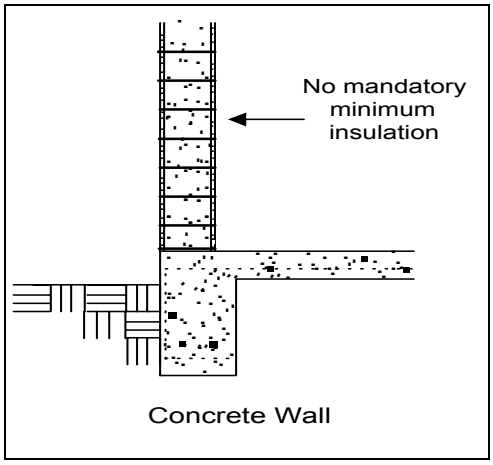
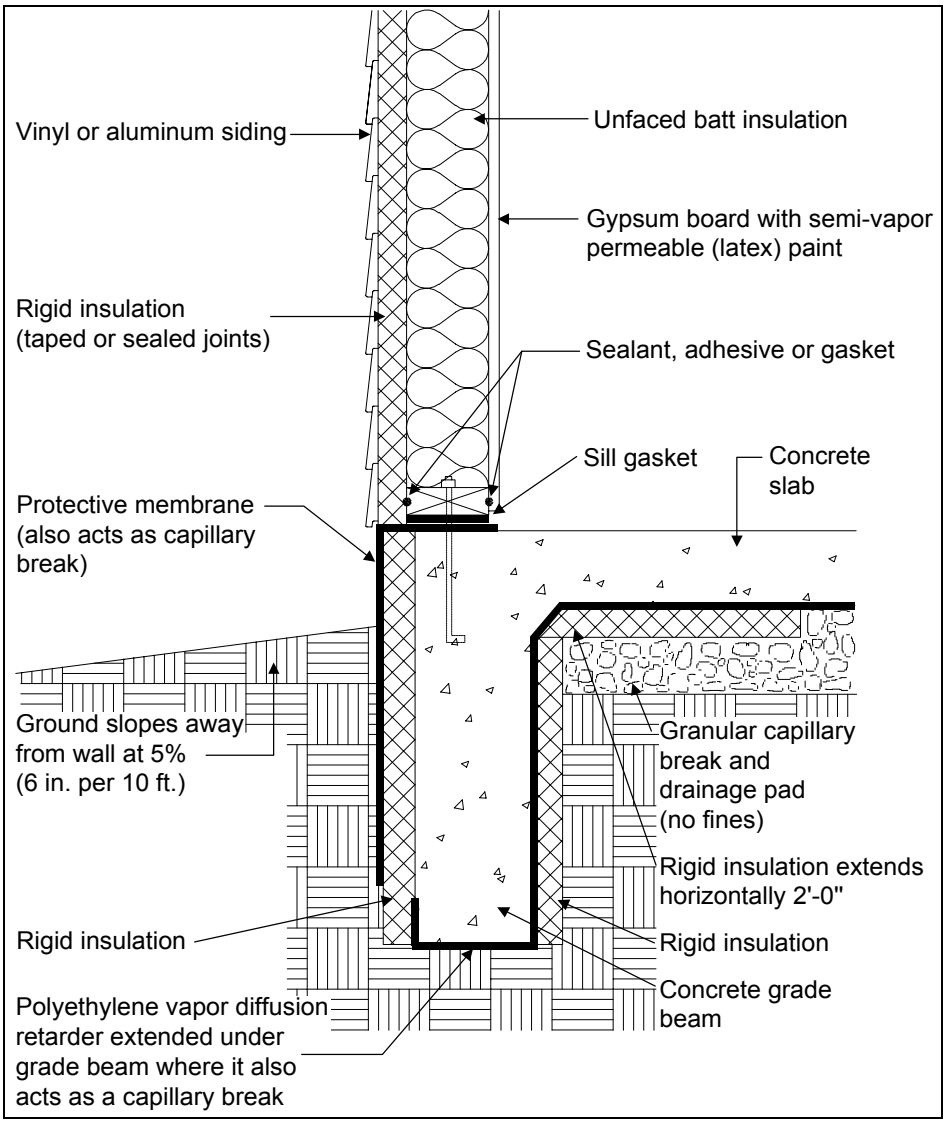


Figure 2-5 – Wall Construction Detail

Wood-Framed Wall with Vinyl or Aluminum Siding, Mandatory Minimum R-13 Insulation or U-factor < 0.088



A change from wood framing to metal framing can significantly affect compliance. These two framing types are not interchangeable. Metal frame wall construction requires rigid insulation in order to meet the mandatory minimum wall insulation level (U-factor less than or equal to 0.088), Therefore, if compliance calculations indicate wood frame construction, either the compliance calculations must be redone with the correct assembly, or a metal frame construction with an equivalent U-factor is required (R-5 rigid insulation with R-15 batt in 2x4 metal framing, 24” o.c.; R-4 rigid insulation with R-19 batt in a 2x6, 24” o.c.).

Rim joists between the stories of a multi-story building are part of the wall and must be insulated to the same level as the wall.

Wall insulation levels should correspond to levels specified on the CF-1R and IC-1 (Insulation Certificate) forms.

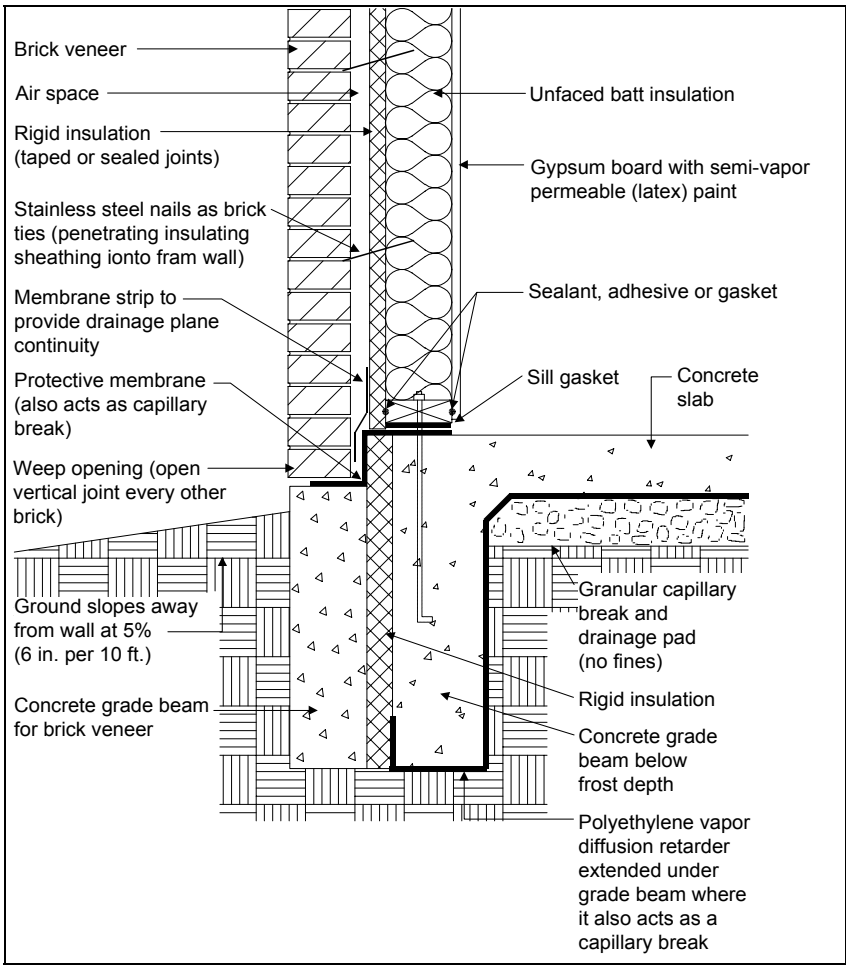
R-13 between wood framing is the minimum mandatory requirement; the package or performance requirement may establish a higher level. This requirement can be met with R-13 cavity insulation in a wood framed wall or with a weighted average U-factor that is equivalent (maximum U-factor 0.088).

Metal framed walls will require rigid insulation to achieve the maximum 0.088 U-factor.

Mass walls that have no framing, such as masonry or concrete, are not required to meet this minimum requirement but may have other insulation requirements as indicated on the CF-1R.

Figure 2-6 – Brick Wall Construction Details

Wood-Framed Wall with Brick Veneer, Mandatory Minimum R-13 Insulation or U-factor ≤ 0.088



The Insulation Certificate (IC-1) must also be completed, signed by the insulation contractor or general contractor. The insulation levels, including rigid insulation, must be consistent with information on the CF-1R. This form is either posted at the job site or made available during inspection and when completed, a copy of this form must be provided to the first occupant of the building.

The R-value of different types of rigid insulation can vary significantly. If rigid insulation is specified on the plans, verify that the type installed is consistent with those specifications.

Because it is difficult to inspect wall insulation between tub/shower enclosures after the enclosure is installed, insulation of these wall sections should be inspected during the framing inspection.

Batt insulation should fill the wall cavity evenly and the kraft or foil facing should be installed per manufacturer recommendations to minimize air leakage and avoid sagging in the insulation.

Wall insulation should extend into the perimeter floor joist (rim joist) cavities along the same plane as the wall.

If a vapor barrier is required, it must face the conditioned space on all installations.

Example 2-2 – Wall Insulation Scenarios

Question

Do new residential buildings or additions consisting of block walls (for example, converting a garage into living space) have to comply with the R-13 minimum wall insulation requirement? If not, what insulation R-value do they need?

Answer

No, the mandatory wall insulation requirement for R-13 applies to frame walls only. The amount of insulation needed, if any, will vary depending on the compliance approach selected. Performance compliance may not require any additional insulation if compliance is achieved without insulation in that space. Prescriptive compliance may require some level of insulation, depending on the climate zone, package selected, and whether the walls are light (block) or heavy mass. Use *Residential Manual* Appendix B, Materials Reference and Appendix I, Framing Calculations, to determine the R-value of the mass wall alone. If additional insulation is required, it must be integral with the wall or installed on the outside of the mass wall (Energy Efficiency Standards, §151(f), Tables No. 1-Z1 through 1-Z16, Note 2).

Question

If I build a steel framed wall with R-13 insulation between the framing, does this comply with mandatory wall insulation requirements?

Answer

No. The wall must have the equivalent U-factor as a wood framed wall with R-13 insulation, which is a maximum of 0.088. To determine if a steel frame assembly meets this U-factor, you have several options. Use one of the pre-calculated assemblies found in Appendix I of the *Residential Manual*. Calculate the U-factor using an ENV-3 for steel frame construction (from Appendix I or from the Nonresidential Manual. Calculate the U-factor using EZFRAME or another method based on ASHRAE zone method.

You cannot use any of the following to document the U-factor of a steel frame wall: Form 3R or any parallel path method, values from Appendix G, Table G-18, in the *Residential Manual* which exceed 0.088 U-factor, or any U-factor which is more than 10% different than values found in or calculated using one of the above referenced sources.

2.2.5 Raised Floor Insulation

Requirement

Wood framed floors must have a minimum of R-13 insulation installed between framing members or the construction must have a U-factor of 0.064 or less. Some areas of the floor can have a U-factor that fails the requirements as long as other areas have a U-factor that exceeds the requirements and the area weighted average U-factor is 0.064 or less. There is an exception to this requirement for qualifying controlled ventilation crawlspaces.

§150(d)

(d) ***Raised Floor Insulation.*** *Raised floors separating conditioned space from unconditioned space shall meet the requirements of either 1 or 2 below:*

1. *Floors shall be insulated between wood framing members with insulation having an installed thermal resistance of R-13 or greater.*
2. *The weighted average U-factor of floor assemblies shall not exceed the U-factor that would result from installing R-13 insulation between wood framing members and accounting for the effects of framing members.*

ALTERNATIVE to §150(d) 1. and 2.: Raised floor insulation may be omitted if the foundation walls are insulated to meet the wall insulation minimums shown in Tables No. 1-Z1 through 1-Z16, a vapor barrier is placed over the entire floor of the crawl

space, and vents are fitted with automatically operated louvers that are temperature actuated.

The raised floor insulation may be of greater insulating value in some areas and of lesser insulating value in other areas of the raised floor, provided the overall weighted average U-factor does not exceed the equivalent R-13 framed value (maximum U-factor less than or equal to 0.064).

Insulation that is not penetrated by framing members, such as rigid insulation over the face of framing, may meet a U-factor equivalent to a wood framed floor with R-13 insulation adjusted for the effects of wood framing (U-factor less than or equal to 0.064). Documenting equivalence may also be shown using Form-3R (see Appendix G, *Glossary, R-Value)*.

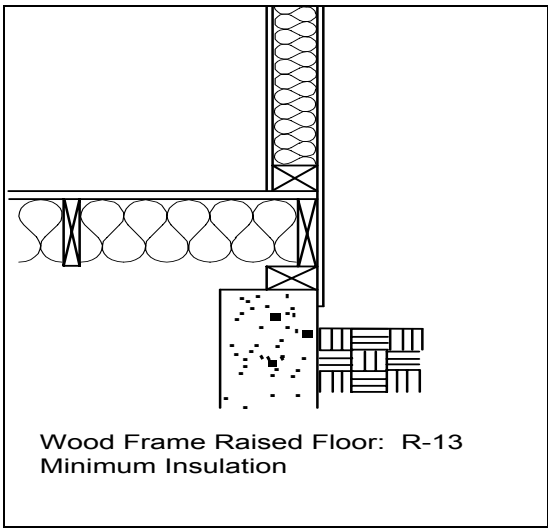
Note: When residences are modeled using an approved computer method (see Chapter 5), R-6 is added to the floor construction to approximate the effect of crawlspace. The maximum raised floor U-factor of 0.064 cannot be met by including the effects of the R-6 crawl space.

An alternative to meeting the minimum raised floor insulation level is to meet all criteria of Controlled Ventilation Crawl Spaces described in Section 8.6. If all eligibility and installation criteria for a controlled ventilated crawl space are met, raised floors above the controlled ventilation crawl space need not meet the minimum insulation requirement.

If the building has a wood raised floor, a minimum of R-13 insulation is required (see Figure 2-7). Check the CF-1R for the required insulation level. The IC-1 must be completed and signed by the installing contractor or the project's general contractor. The insulation levels specified on both forms must be consistent.

For proper installation, floor insulation should be installed in contact with the subfloor, stapled to the floor joists and supported with netting stapled to the underside of floor joists, wires running perpendicular to the joists, or other suitable means. Floor insulation should not cover foundation vents.

Figure 2-7 – Raised Floor Insulation



2.2.6 Slab Edge Insulation

Requirement

When slab edge insulation is required by the *Standards*, the insulation material must be suitable for the application with a water absorption rate no greater than 0.3% and a vapor permeance no greater than 2.0 perm/inch. The insulation must also be protected from physical and UV degradation.

§150(l)

(l) Slab Edge Insulation. Material used for slab edge insulation shall meet the following minimum specifications:

a. Water absorption rate no greater than 0.3 percent when tested in accordance with ASTM-C-271-94.

b. Water vapor permeance no greater than 2.0 perm/inch when tested in accordance with ASTM-E-96-95.

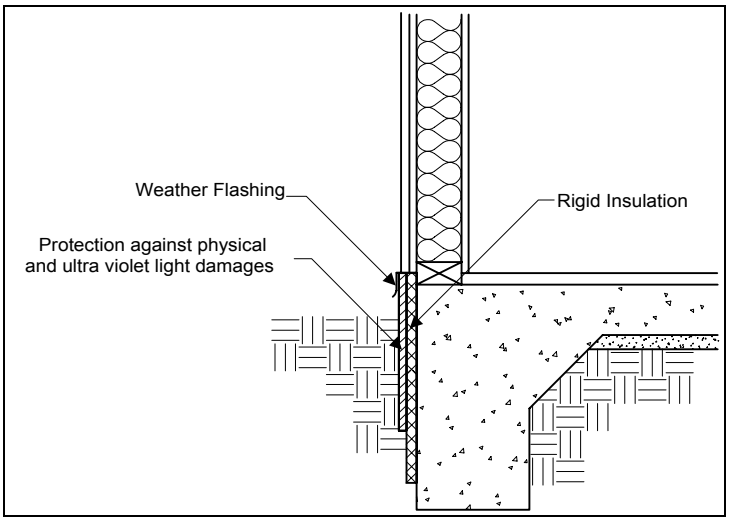
c. Concrete slab perimeter insulation must be protected from physical damage and ultra violet light deterioration.

Slab edge insulation is not mandatory but may be required by the prescriptive package (see Chapter 3), or used for credit in the compliance calculations. The mandatory measures address the material requirements when used for compliance.

Slab edge insulation must be installed with heated slabs. This is not part of the mandatory requirements of the *Standards*, but rather is an eligibility criterion for hydronic heating systems with coils in the slab. Slab edge insulation installed with hydronic heating systems is considered energy neutral and is not modeled in performance calculations. See Section 8.8 for more details on radiant floor heating systems.

Slab edge insulation reduces heat loss through the slab perimeter. When required, as indicated on the CF-1R, the material used must meet the above specifications. An example of an insulating material that meets these specifications is smooth-skin extruded polystyrene.

Figure 2-8 – Slab Edge Insulation



If slab edge insulation is indicated on the CF-1R, it is inspected during the foundation inspection. The IC-1 must also be completed and signed by the installing contractor or the project's general contractor. The insulation levels specified on both forms must be consistent.

The R-value and water absorption / permeance properties should be stamped on the insulation, or the installing contractor should provide manufacturer's literature to verify that these requirements are satisfied.

The slab edge must be protected from physical damage and ultra-violet light deterioration when installed on the exterior footing.

2.2.7 Insulation in Existing Buildings

Requirement

This mandatory requirement deals with the installation of insulation in existing buildings. When insulation is retrofitted in existing attics, the total insulation must be R-30 or greater in areas with less than 5,000 heating degree-days and R-38 or greater in areas with 5,000 heating degree-days or more. When water heaters are insulated, at least R-12 insulation must be used. And, when ducts are insulated, at least R-4.2 insulation must be installed.

§118(d)

(d) ***Installation of Insulation in Existing Buildings****. Insulation installed in an existing attic, or on an existing duct or water heater, shall comply with the applicable requirements of this subsection. If a contractor installs the insulation, the contractor shall certify to the customer, in writing, that the insulation meets the applicable requirements of this subsection.*

1. ***Attics****. If insulation is installed in the existing attic of a low-rise residential building, the R-value of the total amount of insulation (after addition of insulation to the amount, if any, already in the attic) shall be at least R-30, if the building is located in an area that has less than 5,000 heating degree days, or R-38 if the building is located in an area that has 5,000 heating degree days or more.*

   EXCEPTION to Section 118(d)1.: Where the accessible space in the attic is not large enough to accommodate the required R-value, the entire accessible space shall be filled with insulation provided such installation does not violate Section 1505.3 of Title 24, Part 2.

2. *Water Heaters. If external insulation is installed on an existing unfired water storage tank or on an existing back up tank for a solar water heating systems, it shall have an R-value of at least R-12, or the heat loss of the tank surface based on an 80°F water-air temperature difference shall be less than 6.5 Btus per hour per square foot.*

3. *Ducts. If insulation is installed on an existing space conditioning duct, it shall comply with Section 604 of the CMC.*

Attic Insulation

When insulation is installed in an existing, accessible attic it must meet or exceed:

- R-30 if the building is located in an area that has less than 5,000 heating degree days; or
- R-38 if the building is located in an area that has 5,000 heating degree-days or more.

Heating degree-days for 641 California locations can be found in Appendix C.

Water Heater Storage Tank Insulation

There are no requirements for typical storage water heaters. If a permit applicant is adding insulation to an unfired water heater (e.g., holding tank for a boiler) or an existing back-up tank for a solar water heating system, at least R-12 must be added.

Duct Insulation

When a permit applicant is adding insulation to an existing duct system, R-4.2 insulation is required, unless cooling system ducts are installed on the roof or heating system ducts are installed on the roof in an area with more than 8,000 heating degree days where a minimum of R-6.3 insulation is required by the CMC. Heating degree days for 641 California locations can be found in Appendix C. See Section 2.5.7 for installation guidelines.

Installation of ceiling insulation should match guidelines contained in discussions under Sections 2.2.2 Ceiling Insulation, 2.2.3 Loose Fill Insulation, and 2.2.1 Certification of Insulating Material.

An Insulation Certificate (IC-1) must be completed, signed by the insulation contractor or general contractor. This form can either be posted at the job site or given to the building owner.

2.3 Fenestration / Exterior Doors

§101(b)

FENESTRATION PRODUCT is any transparent or translucent material plus any sash, frame, mullions and dividers, in the envelope of a building, including, but not limited to, windows, sliding glass doors, french doors, skylights, curtain walls, garden windows, and other doors with a glazed area of more than one half of the door area.

FENESTRATION SYSTEM means a collection of fenestration products included in the design of a building. (See "fenestration product")

FIELD-FABRICATED FENESTRATION PRODUCT OR EXTERIOR DOOR is a fenestration product or exterior door whose frame is made at the construction site of standard dimensional lumber or other materials that were not previously cut, or otherwise formed with the specific intention of being used to fabricate a fenestration product or exterior door. Field fabricated does not include site-assembled frame components that were manufactured elsewhere with the intention of being assembled on site (such as knocked-down products, sunspace kits, and curtain walls).

MANUFACTURED FENESTRATION PRODUCT is a fenestration product typically assembled before delivery to a job site. A "knocked-down" or partially assembled product sold as a fenestration product must be considered a manufactured fenestration product and meet the rating and labeling requirements for manufactured fenestration products.

SITE-BUILT FENESTRATION PRODUCTS are fenestration products designed to be field-glazed or field assembled units comprised of specified framing and glazing components. Site-built fenestration is eligible for certification under NFRC 100-SB, and may include both vertical glazing and horizontal glazing.

§116

(a) Certification of Fenestration Products and Exterior Doors. Any fenestration product and exterior door, other than field-fabricated fenestration products and field-fabricated exterior doors, may be installed only if the manufacturer has certified to the Commission, or if an independent certifying organization approved by the Commission has certified, that the product complies with all of the applicable requirements of this subsection.

a. Air Leakage. Manufactured fenestration products and exterior doors shall have air infiltration rates not exceeding 0.3 cfm/ft² of window area, 0.3 cfm/ft² of door area for residential doors, 0.3 cfm/ft² of door area for nonresidential single doors (swinging and sliding), and 1.0 cfm/ft² for nonresidential double doors (swinging), when tested according to NFRC-400-95 or ASTM E283-91 at a pressure differential of 75 pascals or 1.57 pounds/ft², incorporated herein by reference.

b. U-factor and SHGC. Fenestration products shall:

A. Be certified for overall U-factors as rated in accordance with the National Fenestration Rating Council's NFRC 100 (1997) and be certified for overall SHGC, as rated in accordance with the National Fenestration Rating

Council's NFRC 200 (1995), incorporated herein by reference, or such values shall be certified in accordance with Tables 1-D and 1E and labeled as set forth in Section 10-111; and

B. *Have a temporary label or label certificate (for site-built products) meeting the requirements of Section 10-111(a)(1), not to be removed before inspection by the enforcement agency, listing the certified U-factor and SHGC, and certifying that the air leakage requirements of Section 116(a)1. are met for each product line; and*

C. *Have a permanent label or label certificate (for site-built products) meeting the requirements of Section 10-111(a)(2) if the product is rated using NFRC procedures.*

EXCEPTION to Section 116(a): Fenestration products removed and reinstalled as part of a building alteration or addition.

…

EXCEPTION 3 to Section 116 (a) 2:Skylights and site-assembled horizontal glazing shall have SHGC values and U-factors determined in accordance with NFRC procedures or default values set forth in Appendix I of the Nonresidential ACM Manual. Documentation shall be provided as set forth in Appendix I of the Nonresidential ACM Manual.

(b) Installation of Field-Fabricated Fenestration Products and Exterior Doors. Field-fabricated fenestration products and exterior doors shall be caulked between the fenestration products or exterior door and the building, and shall be weatherstripped.

EXCEPTION to Section 116(b): Unframed glass doors and fire doors.

Table 2-2 – Default Fenestration Product U-factors (From Table 1-D of §116 of the Standards)

Frame Type[1]	***Product Type[2]***	***Single Pane U-factor***	***Double Pane U-factor[3]***
Metal	Operable	1.28	0.87
Metal	Fixed	1.19	0.72
Metal	Greenhouse/Garden window	2.26	1.40
Metal	Doors	1.25	0.85
Metal	Skylight	1.72	0.94
Metal, Thermal Break	Operable		0.71
Metal, Thermal Break	Fixed		0.60
Metal, Thermal Break	Greenhouse/Garden window		1.12
Metal, Thermal Break	Doors		0.64
Metal, Thermal Break	Skylight		0.80
Non-Metal	Operable	0.99	0.60
Non-Metal	Fixed	1.04	0.57
Non-Metal	Doors	0.99	0.55
Non-Metal	Greenhouse/Garden windows	1.94	1.06
Non-Metal	Skylight	1.47	0.68

1 Metal includes any field-fabricated product with metal cladding. Non-metal framed manufactured fenestration products with metal cladding must add 0.04 to the listed U-factor. Non-Metal frame types can include metal fasteners, hardware, and door thresholds. Thermal break product design characteristics are:

a. The material used as the thermal break must have a thermal conductivity of not more than 3.6 Btu-inch/hr/ft^2/°F,

b. The thermal break must produce a gap of not less than 0.210", and

c. All metal members of the fenestration product exposed to interior and exterior air must incorporate a thermal break meeting the criteria in a and b above.

In addition, the fenestration product must be clearly labeled by the manufacturer that it qualifies as a thermally broken product in accordance with this standard.

The values for non-metal can be used for unframed windows.

2 Glass Block may use the values for double pane windows of the same frame type used with the glass block.

3 For all dual glazed fenestration products, adjust the listed U-factors as follows:

a. Subtract 0.05 for spacers of 7/16" or wider.

b. Subtract 0.05 for products certified by the manufacturer as low-E glazing.

c. Add 0.05 for products with dividers between panes if spacer is less than 7/16" wide.

d. Add 0.05 to any product with true divided light (dividers through the panes).

Table 2-3 – Default Solar Heat Gain Coefficients (From Table 1-E of §116 of the Standards)

Frame Type	***Product[1]***	***Glazing***	***Single Pane***	***Double Pane***
Metal	Operable	Clear	0.80	0.70
	Fixed	Clear	0.83	0.73
	Operable	Tinted	0.67	0.59
	Fixed	Tinted	0.68	0.60
Metal, Thermal Break	Operable	Clear	0.72	0.63
	Fixed	Clear	0.78	0.69
	Operable	Tinted	0.60	0.53
	Fixed	Tinted	0.65	0.57
Non-Metal	Operable	Clear	0.74	0.65
	Fixed	Clear	0.76	0.67
	Operable	Tinted	0.60	0.53
	Fixed	Tinted	0.63	0.55

1 The values for non-metal can be used for unframed windows. Glass Block may use the values for double pane windows of the same frame type used with the glass block

The National Fenestration Rating Council (NFRC) publishes the Certified Product Directory, containing NFRC certified U-factors and SHGC for thousands of products. This directory can be purchased by contacting:

NFRC
1300 Spring Street, Suite 120
Silver Springs, MD 20901
(301) 589-6372

Compliance calculations can use NFRC labeled product data or default SHGC and U-factors depending on the fenestration category (see Table 2-4 and Table 2-5. There are three main categories of fenestration products – field-fabricated fenestration, manufactured fenestration, and site-built fenestration. See 8.4.1 for definitions of these categories. The CF-6R must be completed by the installer, listing all the fenestration products installed in the dwelling unit.

Field-fabricated Products. Field-fabricated products are required to limit air leakage by weatherstripping, caulking, or some other appropriate means as described below in "Joints and Other Openings." Field-fabricated products may only use default values (from Table 2-2 and Table 2-3) for determining U-factors and SHGC. Temporary and permanent labels are not required for field-fabricated products.

Manufactured Fenestration and Site-built Fenestration. Fenestration products must have a temporary label indicating the U-factor and SHGC based on either the *CEC Default* or *NFRC Rating Procedures.* Site built fenestration products may have a 'label certificate' in accordance with NFRC 100-SB instead of a label. Site built fenestration products not rated in accordance with NFRC 100-SB may have a 'label certificate' provided by the manufacturer that includes the same information as provided in the NFRC 100-SB label certificate instead of a label.

Each manufactured fenestration product must:

- have a temporary label, not to be removed before inspection by the enforcement agency, listing the certified U-factor, SHGC, and certifying that the air infiltration requirements of §116 are met (see Figure 2-9); and
- have a permanent label listing, the U-factor, certifying organization, and rating procedures or a label to allow tracking back to the original certification information on file with the certifying organization.

The U-factor and SHGC values on the window label must be less than, or equal to, the values used for compliance and documented on the CF-1R.

Exterior Doors. Exterior doors are required to meet the following requirements of the *Standards*:

- Manufactured exterior doors must be certified as meeting an air leakage rate of 0.3 cfm/ft² of door area.
- Comply with the requirements of §116(b) and §117, as described below in "Joints and Other Openings."

Any door with more than one half of the door area consisting of glass is considered a fenestration product. The standards define an exterior door as:

EXTERIOR DOOR is a door through an exterior partition that is opaque or has a glazed area that is less than or equal to one-half of the door area. Doors with a glazed area of more than one half of the door area are treated as a fenestration product.

Table 2-4 – Methods for Determining U-factors

U-factor Determination Method	Fenestration Category: Manufactured Windows	Site-Built Fenestration	Field-Fabricated Fenestration
NFRC 100 (1997)	✓	✓	
NFRC 100-SB (2000)		✓	
Table 2-2 (*Standard* Table 1-D)	✓	✓	✓

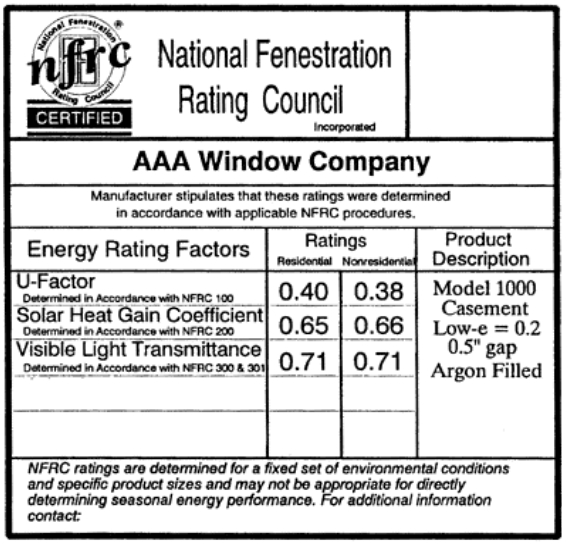
Table 2-5 – Methods for Determining Solar Heat Gain Coefficients

SHGC Determination Method	Fenestration Category: Manufactured Windows	Site-Built Fenestration	Field-Fabricated Fenestration
NFRC 200 (1995)	✓	✓	
NFRC 100-SB (2000)		✓	
Table 2-3 (*Standard* Table 1-E)	✓	✓	✓

Fenestration and shading products play a major role in not only the building's energy use but can affect the operation of the HVAC system and the comfort of the occupants. Check all installed fenestration including windows, doors with over one-half glass, and glazed skylights.

Check the CF-6R completed by the installer and compare it to the temporary label. All fenestration products must have a temporary label indicating the U-factor, Solar Heat Gain Coefficient (SHGC) and certification of air infiltration requirements (only field-fabricated products are exempt from labeling requirements).

Figure 2-9 – Temporary Label



CERTIFIED

National Fenestration Rating Council Incorporated

AAA Window Company

Manufacturer stipulates that these ratings were determined in accordance with applicable NFRC procedures.

Energy Rating Factors	Ratings: Residential	Ratings: Nonresidential	Product Description
U-Factor (Determined in Accordance with NFRC 100)	0.40	0.38	Model 1000 Casement Low-e = 0.2 0.5" gap Argon Filled
Solar Heat Gain Coefficient (Determined in Accordance with NFRC 200)	0.65	0.66	
Visible Light Transmittance (Determined in Accordance with NFRC 300 & 301)	0.71	0.71	

NFRC ratings are determined for a fixed set of environmental conditions and specific product sizes and may not be appropriate for directly determining seasonal energy performance. For additional information contact:

The label may separately list the U-factor, SHGC, and visible light transmission for residential and nonresidential window sizes. The residential U-factor and SHGC data is all that matters with the low-rise residential standards. The nonresidential data can be ignored and visible light transmission is not regulated by the *Standards*.

Example 2-3 – Mandatory Measures Applied to Fenestration

Question

My home will have a combination of window types, including fixed, operable, wood, metal, etc. None of the windows are rated by NFRC. What are the options for showing compliance with the *Standards*.

Answer

Since none of the windows are rated by NFRC, you must select U-factors and SHGC values from the default tables (see Table 2-2 and Table 2-3). If any of the U-factors or SHGCs do not comply with the prescriptive requirements, you must use the performance method (see chapter 5). To simplify data entry into the compliance software, you can choose the value from Table 2-2 that is the highest of any of the windows, and use this for all windows. However, you must use the appropriate SHGC from Table 2-3 for each window type individually. However, the latter approach will make it more difficult to comply with the *Standards*.

Question

When windows are labeled with a default value, are there any special requirements that apply to the label?

Answer

There are two criteria that apply to fenestration products labeled with default values. First, the Administrative Regulations (§10-111) require that the words “CEC Default U-factor” and “CEC Default SHGC” appear on the temporary label in front of or before the U-factor or SHGC (i.e., not in a footnote). Second, the U-factor and SHGC for the specific product must be listed. If multiple values are listed on the label, the manufacturer must identify, in a permanent manner, the appropriate value for the labeled product. Marking the correct value may be done in the following ways only:

- Circle the correct U-factor and SHGC (permanent ink).
- Black out all values except the correct U-factor and SHGC (permanent ink).
- Make a hole punch next to the appropriate values.

Question

What U-factor do I use for glass block? What solar heat gain coefficient do I use for clear glass block? Does it need a label?

Answer

For glass block, use the U-factor and SHGC values from Table 2-2 and Table 2-3 for double pane glass for the frame type in which the glass blocks are installed. Unframed glass block is the same as unframed window, which is the same as non-metal fixed frame. The U-factor for unframed glass block is therefore 0.57. The SHGC depends on whether the glass block is tinted. For this example, the glass block is clear, therefore the SHGC is 0.67. Glass block is considered a field-fabricated product and therefore does not need a label.

Question

Is there a default U-factor for the glass in sunrooms?

Answer

For the horizontal portion of the sunroom, use the U-factor for skylights. For the vertical portion, use the U-factors for either fixed, operable or doors, as appropriate. Use either default or NFRC-rated U-factors. As a simplifying alternative, the manufacturer may label the entire sunroom with the highest U-factor of any of the individual fenestration types within the assembly.

Question

How are French doors treated in compliance documentation, for example the U-factor and dimensions? How can I determine a solar heat gain coefficient for French doors when 50 percent or more of the door area is glass?

Answer

French doors with 50 percent or more of the door area in glass are defined as fenestration products (101, Exterior Door) and are covered by the National Fenestration Rating Council (NFRC) Rating and Certification Program. You may use either an NFRC-rated U-factor or a default doors U-factor. The fenestration area for compliance documentation is the entire rough opening of the door (not just the glass area).

The solar heat gain coefficient (SHGC) for French doors may be determined in one of two ways:

1. Use the NFRC rated and labeled SHGC.
2. Refer to Table 2-3. The SHGCs in this table have been pre-calculated based upon glazing type, framing type, and interior shade type.

If a door has 50% or less of its surface area made up of glass, either the entire door may be treated as fenestration or the door may be treated as a combination of opaque surface area and the glass area (glass plus a two-inch frame extending on all sides). If the entire door is treated as fenestration, either NFRC ratings or default table values may be used for determining U-factor and SHGC. If the door is treated as a combination of opaque surface area and glass area, the U-factor and the SHGC for the glass area is taken from the default tables (the remaining door area is modeled as an opaque surface). Changing a door without any other changes to an existing building is considered a replacement of a fenestration product, and therefore U-factor or SHGC requirements are not applicable.

Question

As a manufacturer of fenestration products, I place a temporary label with the air infiltration rates on my products (§116(a)). Can you clarify which products must be tested and certified?

Answer

Each product line must be tested and certified for air infiltration rates. Features such as weather seal, frame design, operator type, and direction of operation all effect air leakage. Every product must have a temporary label certifying that the air infiltration requirements are met. This temporary label may be combined with the temporary U-factor label.

Question

Is a custom window “field-fabricated” for purposes of meeting air infiltration requirements?

Answer

No. Most custom windows are manufactured and delivered to the site either completely assembled or “knocked down”, which means they are a manufactured product. A window is considered field fabricated when the windows are assembled at the building site from the various elements that are not sold together as a fenestration product (i.e., glazing, framing and weatherstripping). As stated in the definition, “field fabricated does not include site assembled frame components that were manufactured elsewhere with the intention of being assembled on site (such as knocked down products, sunspace kits, and curtainwalls).”

2.4 Infiltration and Moisture Control

Note: Infiltration through fenestration products is addressed in the previous section.

2.4.1 Joints and Other Openings

§117

(a) Joints and other openings in the building envelope that are potential sources of air leakage shall be caulked, gasketed, weatherstripped, or otherwise sealed to limit infiltration and exfiltration.

Air leakage through cracks around windows, doors, walls, roofs and floors can result in higher energy use for home heating and cooling than necessary. The *Standards* contain a number of requirements to control infiltration and exfiltration.

The following openings in the building envelope must be caulked, gasketed, weather-stripped or otherwise sealed (see Figure 2-10):

- Exterior joints around window and door frames, including doors between the house and garage, between interior HVAC closets and unconditioned space, between attic access and conditioned space, and between wall sole plates, floors, exterior panels and all siding materials;
- Openings for plumbing, electricity, and gas lines in exterior walls, ceilings and floors;
- Openings in the attic floor (such as where ceiling panels meet interior and exterior walls and masonry fireplaces); and
- Exhaust duct from a clothes dryer needs to have a damper; and all other such openings in the building envelope.

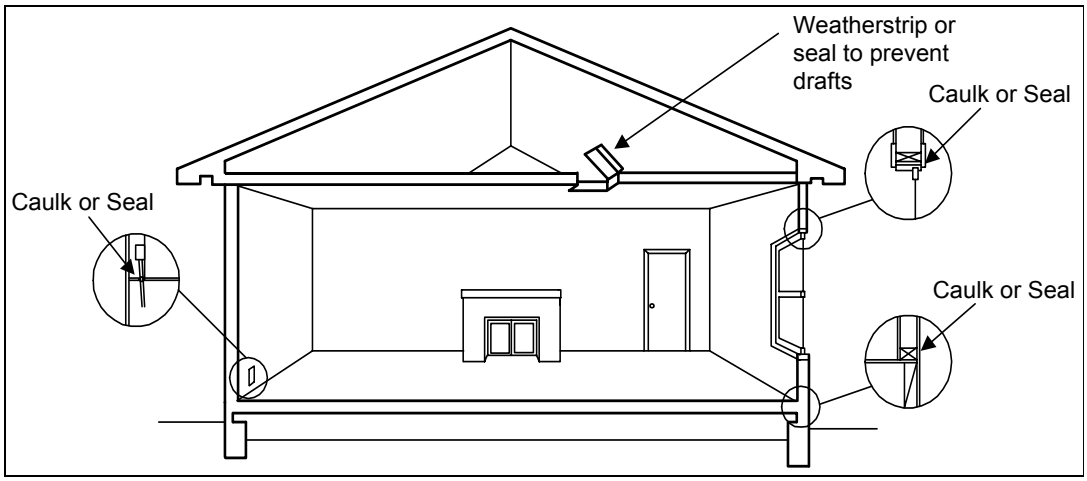
Alternative approved techniques may be used to meet the mandatory caulking requirements for exterior walls. These include, but are not limited to:

- Continuous stucco
- Caulking and taping all joints between wall components (e.g., between slats in wood slat walls)
- Building wraps
- Rigid wall insulation

Openings in exterior walls are often needed to accommodate gas, plumbing or electrical lines. Any openings in the building envelope separating conditioned space from unconditioned space must be sealed to prevent air leakage. A proper seal can be verified by checking that the opening is continuously caulked all around and that no light can be seen around the opening. Caulking must also be applied between the bottom plate of the wall framing and the subfloor (see Figure 2-10).

Weather-stripping is required on all operable windows and doors. This includes doors between the garage and the house, between interior HVAC closets and conditioned space, and between the attic access and conditioned space.

Figure 2-10 – Caulking and Weather Stripping



2.4.2 Vapor Barrier

§150(g), 101(b)

(g) ***Vapor Barriers.*** *In Climate Zones 14 and 16 as shown in Figure No. 1-A, a vapor barrier shall be installed on the conditioned space side of all insulation in all exterior walls, unvented attics, and unvented crawl spaces to protect insulation from condensation.*

If a building has a controlled ventilation crawl space (CVC), a vapor barrier shall be placed over the earth floor of the crawl space to reduce moisture entry and protect insulation from condensation, as specified in the ALTERNATIVE to Section 150(d).

VAPOR BARRIER is a material that has a permeance of one perm or less and that provides resistance to the transmission of water vapor.

A vapor barrier or retarder is a special covering over framing and insulation that protects the wall assembly components from possible damage due to moisture buildup. When moisture gravitates from inside the house toward the outdoors it can condense, causing the insulation to lose its effectiveness.

In Climate Zones 14 and 16 only, a continuous vapor barrier, lapped or joint sealed, must be installed on the conditioned space side of all insulation in all exterior walls, on the floors of unvented attics, and on floors over unvented crawl spaces to protect insulation from condensation. If a building has a controlled ventilation crawl space (see Section 8.6), a vapor barrier shall be placed over the earth floor of the crawl space to reduce moisture entry and protect insulation from condensation.

The *Standards* define a vapor barrier as material with a permeance of one perm or less. A perm is a measure of resistance to the transmission of water vapors and is equal to one grain of water vapor transmitted per square foot per hour per inch of mercury pressure difference. The *Commission* has determined that interior painted surfaces may qualify for meeting the vapor barrier requirement if the paint product is tested to have a rating of at least one perm. For all types of vapor barriers, care should be taken to seal penetrations such as electric outlets on exterior walls.

Products such as a continuous polyethylene sheet or wall board with foil backing qualifies as vapor barrier, if according to the appropriate testing procedure, it meets the vapor barrier permeance rating of one perm or less. Kraft paper backing on batt insulation qualifies if the paper backing meets the vapor barrier permeance rating, and is properly installed. For proper installation, the Kraft paper should be installed per manufacturer instructions.

If a building is being constructed in climate zone 14 or 16, a continuous vapor barrier is required. One of several products should be indicated on the plans to comply with this requirement. Acceptable products include:

- Continuous polyethylene sheet,
- Wall board with foil backing,
- Kraft facing, or
- Any product that has appropriate test data verifying a moisture migration resistance of one perm or less.

Kraft paper backing on batt insulation, under certain circumstances, may be used to meet the continuous vapor barrier requirement. Specifically, the paper backing must meet the vapor barrier permeance rating and the product must be installed properly. For proper installation of batt insulation with Kraft paper backing:

1. Kraft paper should *not* be stapled to the sides of framing members; instead, the Kraft paper tabs on each side of the insulation batt must be fastened to the face of the conditioned side of the framing member, and
2. At the ends of the insulated cavity, the Kraft paper must overlap the framing members to create a continuous barrier at the wall cavity.

2.4.3 Special Infiltration Barrier

The mandatory requirement for infiltration barriers is no longer applicable. The prescriptive packages (Package B) used to require a special infiltration barrier in some climates. Package B was deleted with the 2001 update to the *Standards* and none of the prescriptive packages now require a special infiltration barrier.


§150(f)

Infiltration Barrier. If an infiltration barrier is installed to meet the requirements of Section 151, it must have an air porosity of less than 5 ft³ per hour per square foot per inch of mercury pressure difference when tested in accordance with the requirements of ASTM E283-91. If a vapor barrier functions as an infiltration barrier it shall be located on the conditioned side of the exterior framing.

2.4.4 Fireplaces, Decorative Gas Appliances and Gas Logs

§150(e) has requirements to limit infiltration associated with fireplaces, decorative gas appliances and gas logs. The code language is shown below.


§150(e)

1. If a masonry or factory-built fireplace is installed, it shall have the following:

A. Closable metal or glass doors covering the entire opening of the firebox;

B. A combustion air intake to draw air from the outside of the building directly into the firebox, which is at least 6-square inches in area and is equipped with a readily accessible, operable, and tight-fitting damper or combustion air control device; and

EXCEPTION to Section 150(e)1.B.: An outside combustion air intake is not required if the fireplace will be installed over concrete slab flooring and the fireplace will not be located on an exterior wall.

C. A flue damper with a readily accessible control.

EXCEPTION to Section 150(e)1.C.: When a gas log, log lighter, or decorative gas appliance is installed in a fireplace, the flue damper shall be blocked open if required by the manufacturer's installation instructions or the California Mechanical Code.

2. *Continuous burning pilot lights and the use of indoor air for cooling a firebox jacket, when that indoor air is vented to the outside of the building, are prohibited.*

Because conditioned air can escape through a fireplace chimney, fireplace efficiency can be greatly improved through proper air control that the *Standards* require in the form of specific air control measures. Reduced infiltration is also a benefit when the fireplace is not operating (the majority of the time for most houses).

Installation of factory-built or masonry fireplaces (see Figure 2-11) must include:

- Doors covering the entire opening of the firebox that can be closed when the fire is burning.
- A combustion air intake that is at least 6 square inches equipped with a readily accessible, operable and tight-fitting damper.
- A flue damper with a readily accessible control.

These requirements do not apply to decorative gas appliances. Continuous burning pilot lights and the use of indoor air for cooling a firebox jacket, when that indoor air is vented to the outside of the building, are prohibited

Note: When a gas log, log lighter, or decorative gas appliance is installed in a fireplace; the flue damper shall be blocked open if required by manufacturer's installation instructions or the California Mechanical Code.

Fireplace requirements:

- closable metal or glass doors;
- combustion air intake (six square inch) for all fireplaces over a raised floor;
- combustion air intake (six square inch) for all fireplaces on exterior walls of slab on grade floors (see the CMC requirements related to outside combustion air);
- readily accessible flue damper control;
- no continuously burning pilot light; and
- no use of indoor air to cool firebox jacket.

Note: When a gas log, log lighter or decorative gas appliance is installed in a fireplace, the flue damper shall be blocked open if required by the manufacturer's installation instructions or the California Mechanical Code.

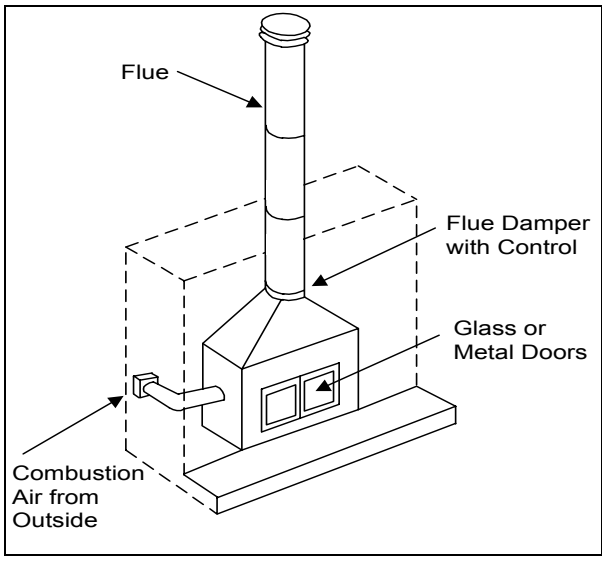
Free Standing Decorative gas appliance requirements:

- no continuously burning pilot light; and
- no use of indoor air to cool firebox jacket

Gas log requirement:

- no continuously burning pilot light.

Figure 2-11 – Fireplace Installation



Example 2-4 – Decorative Gas Appliances

Question

Are closable glass or metal doors required for decorative gas appliances?

Answer

No. The only requirement of *Standards* §150(e) that applies to decorative gas appliances is the prohibition on continuously burning pilot lights (§150(e)2). If there is a question about whether a device is a fireplace, which requires glass doors, the distinction is that a fireplace has a hearth, chamber or other place in which a solid fuel fire or a decorative gas log set may be burned, while a decorative gas appliance is for visual effect only and merely simulates a fire in a fireplace (§101.)

Question

If I want to have a gas log or some other device in the fireplace of my home, can I block open the damper? Can it have a standing pilot light?

Answer

§150(e)1 (which contains the requirements for fireplaces, decorative gas appliances, and gas logs), allows the flue damper to be blocked open if required by either the manufacturer's installation instructions or the California Mechanical Code. Continuously burning pilot lights in these appliances are prohibited by §150(e)2.

Question

§150(e)2 of the *Standards* states that no fireplace, decorative gas appliance or gas log can be installed if it has a continuously burning pilot light. The California Mechanical Code requires all gas appliances installed in California to have a manually operated shut-off valve, accessible to the inhabited space. Does this shut-off valve meet the intent of this section?

Answer

Not if the pilot light must be manually extinguished when the appliance is off. A unit that meets the intent of this section will have a pilot light that cannot stay on when the unit is off.

Question

A building plan specifies a freestanding gas heater that is very decorative, however, the equipment is vented and is rated as a room heater. Is it acceptable that this appliance have a pilot light.

Answer

Yes. Since this equipment is rated as a room heater, it can have a continuous burning pilot light.

Question

Do decorative gas appliances need glass or metal doors?

Answer

As defined in §101 of the *Standards*, decorative gas appliances do not need doors. The door requirement applies to masonry or factory-built fireplaces only (§150(e)1). If a decorative gas appliance is installed inside a fireplace, the fireplace needs doors. Consult with the manufacturer of the decorative gas appliance regarding combustion air requirements.

2.5 Space Conditioning

The design and installation of a building's space conditioning system has a significant impact on energy consumption and peak demand. As result, the *Standards* set a number of mandatory requirements related to space conditioning systems, including:

- Systems and Equipment Certification, Appliance Efficiency Regulations
- Space Conditioning Sizing
- Setback Thermostats
- Heat Pump Controls
- Insulation for Refrigerant Lines in Split System
- Ducts, Plenums, and Fans
- Duct Installation Standards
- Pilot Lights

The following sections discuss each of the relevant mandatory measures in detail.

2.5.1 Systems and Equipment Certification, Appliance Efficiency Regulations


§110

Section 110: Systems and Equipment – General.

Sections 111 through 119 establish requirements for the manufacture, construction, and installation of certain systems, equipment, and building components that are installed in buildings regulated by Title 24, Part 6. Systems, equipment, and building components listed below may be installed only if:

(a) The manufacturer has certified that the system, equipment, or building component complies with the applicable manufacture provisions of Sections 111 through 119; and

(b) The system, equipment, or building component complies with the applicable installation provisions of Sections 111 through 119.

No system, equipment, or building component covered by the provisions of Section 111 through Section 119 that is not certified or that fails to comply with the applicable installation requirements may be installed in a building regulated by Title 24, Part 6.

The systems, equipment, and building components covered are:

Appliances regulated by the Appliance Efficiency Regulations (Section 111)

Other space conditioning equipment (Section 112)

Other service water heating systems and equipment (Section 113)

Pool and spa heating systems and equipment (Section 114)

Gas appliances (Section 115)

Doors, windows, and fenestration products (Section 116)

Joints and other openings (Section 117)

Insulation and Cool Roofs (Section 118)

Lighting control devices (Section 119)


§111

Section 111: Mandatory Requirements for Appliances Regulated by the Appliance Efficiency Regulations.

Any appliance for which there is a California standard established in the Appliance Efficiency Regulations may be installed only if the manufacturer has certified to the Commission, as specified in those regulations, that the appliance complies with the applicable standard for that appliance. See Appendix 1-A for availability of directories of certified appliances.

Only HVAC equipment certified by manufacturers as complying with applicable *Appliance Efficiency Regulations* at the time of manufacture may be installed. Regulated equipment may not be sold in California unless it is certified. This includes the following HVAC equipment types:

- Room air conditioners
- Room air conditioning heat pumps
- Central air conditioners with a cooling capacity of less than 135,000 Btu/hr
- Central air conditioning heat pumps
- Gas-fired central furnaces
- Gas-fired boilers
- Gas-fired furnaces
- Gas-fired floor furnaces
- Gas-fired room heaters
- Gas-fired duct furnaces
- Gas-fired unit heaters

A summary of appliance efficiency regulations for gas-fired space heaters, air conditioners and heat pumps is given under the definition of the efficiency descriptors in Appendix G, *Glossary*, under *AFUE, SEER* and *HSPF.*

The *Standards* do *not* require certification for:

- Infrared heaters
- Nonstorage-type electric water heaters

- Electric resistance heaters
- Oil-fired furnaces (some are voluntarily listed with certified gas-fired furnaces)

Federal appliance efficiency standards require that:

1. Gas fan type central furnaces with an input rate less than 225,000 Btu/hr and manufactured on or after January 1, 1992, must be certified by the manufacturer to have an Annual Fuel Utilization Efficiency (AFUE) of 78% or greater.
2. Boilers with an input rate less than 300,000 Btu/hr and manufactured on or after January 1, 1992, must be certified by the manufacturer to have an AFUE of 75% or greater for gas steam type boilers and 80% or greater for all other boilers.
3. Split system air source air conditioners or heat pumps with an output rate less than 65,000 Btu/hr and manufactured on or after January 1, 1992, must be certified by the manufacturer to have a Seasonal Energy Efficiency Ratio (SEER) of 10.0 or greater.
4. Single packaged air source air conditioners or heat pumps with an output rate less than 65,000 Btu/hr and manufactured on or after January 1, 1993, must be certified by the manufacturer to have an SEER of 9.7 or greater.

California efficiency requirements for larger capacity equipment than covered above are specified in §112 of the *Standards.*

If any equipment does not meet the federal appliance efficiency standards, it may not be sold in California. Any equipment covered by the *Appliance Efficiency Regulations* and sold in California must have the date of manufacture permanently displayed in an accessible place on that equipment. This date is frequently included as part of the serial number.

Note: Equipment manufactured before the effective date of a new standard may be sold and installed in California indefinitely, as long as a performance approach demonstrates compliance of the building using the lower efficiency appliances.

The person who signs off on the Installation Certificate (CF-6R) is required to certify that the actual equipment installed meets or exceeds the requirements of the *Appliance Efficiency Regulations* and that the equipment is equivalent to, or more efficient than the equipment described on the Certificate of Compliance attached to the plans.

Heating and Air-conditioning Systems

Verify that the make and model number of the installed unit matches that listed on the Installation Certificate (CF-6R). For furnaces, the make and model number can be verified by removing the front plate and checking the nameplate data. For cooling units, the nameplate data is typically located on the unit's case (cowling).

The person who signs off on the Installation Certificate (CF-6R) is certifying that the actual equipment installed meets or exceeds the requirements of the *Appliance Efficiency Regulations* and that it is equivalent to, or more efficient than, the equipment described on the Certificate of Compliance attached to the plans. Compare the CF-6R data to the CF-1R data shown on the plans.

2.5.2 Space Conditioning Sizing

§150(h)

(h) Space Conditioning Sizing

1. Building design heat loss rate and design heat gain rate, shall be determined using a method based on any one of the following:

A. *The American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) Handbook and Product Directory, Equipment Volume (1996), HVAC Applications Volume (1995), and Fundamentals Volume (1993), or*

B. *The Sheet Metal Air Conditioning Contractors National Association (SMACNA) Installation Standards for Residential Heating and Air Conditioning Systems, or*

C. *The Air Conditioning Contractors Of America (ACCA) Manual J.*

The design heat loss rate and design heat gain rate are two of the criteria that shall be used for equipment sizing and selection.

NOTE to Section 150(h)1.: Heating Systems must meet the minimum heating capacity required by UBC Section 310.11. The furnace output capacity and other specifications are published in the Commission's directory of certified equipment or other directories approved by the Commission.

2. *Design Conditions.*

For the purpose of sizing the space conditioning (HVAC) system, the indoor design temperatures shall be 70 degrees Fahrenheit for heating and 78 degrees for cooling. The outdoor design temperatures for heating shall be no lower than the Winter Median of Extremes column. The outdoor design temperatures for cooling shall be from the 0.5 percent Summer Design Dry Bulb and the 0.5 percent Wet Bulb columns for cooling, based on percent-of-year in ASHRAE publication SPCDX: Climate Data for Region X, Arizona, California, Hawaii, and Nevada, 1982, incorporated herein by reference.

The sizing of residential heating systems is regulated by the *Uniform Building Code (UBC)* and the *Standards*. The UBC requires that the heating system be capable of maintaining a temperature of 70 ºF at a distance three feet above the floor throughout the conditioned space of the building.

Indoor Design Temperatures for sizing calculations are 70 ºF for heating and 78 ºF for cooling.

Design conditions for 641 California locations, from the ASHRAE publication *Climatic Data For Region X: Arizona, California, Hawaii, Nevada by ASHRAE* (Fifth Edition, May 1982, supplement November 1994), are contained in Appendix C. If the actual city location for a project is not included in the ASHRAE listing, or if the data given for a particular city does not match the conditions at the actual site as well as that given for another nearby city, consult the local building department for guidance.

The load calculations must be submitted with compliance documentation when requested by the building department.

The mechanical contractor, who installs the equipment, completes and signs the Installation Certificate (CF-6R) and is ultimately responsible for proper sizing and equipment selection.

The calculated heat gain and heat loss rates (load calculations) are just two of the criteria for sizing and selecting equipment. The load calculations may be prepared by: (1) the documentation author and submitted to the mechanical contractor for signature, (2) a mechanical engineer, or (3) the mechanical contractor who is installing the equipment.

The load calculations do not need to be submitted with compliance documentation unless requested by the building department.

2.5.3 Setback Thermostats

§150(i)

(i) ***Setback Thermostats.*** *All heating and/or cooling systems other than wood stoves shall have an automatic thermostat with a clock mechanism or other setback mechanism approved by the Executive Director that shuts the system off during periods of non-use and that allows the building occupant to automatically set back the thermostat set points for at least 2 periods within 24 hours.*

EXCEPTION to Section 150(i): Gravity gas wall heaters, gravity floor heaters, gravity room heaters, non-central electric heaters, room air conditioners, and room air conditioner heat pumps need not comply with this requirement.

Additionally, room air conditioner heat pumps need not comply with Section 112(b). The resulting increase in energy use due to elimination of the setback thermostat shall be factored into the compliance analysis in accordance with a method prescribed by the Executive Director.

All heating and/or cooling systems must have an automatic setback thermostat with a clock mechanism that shuts the system off during periods of non-use and that allows the building occupant to automatically set back the thermostat set points for at least two periods within 24 hours.

An exception applies only for computer performance compliance when a “non-setback” control is modeled for the listed non-central space-conditioning systems.

If more than one piece of heating equipment is installed in a residence or dwelling unit, the set-back requirement may be met either by controlling all heating units by one setback thermostat or by controlling each unit with a separate setback thermostat. Separate heating equipment units may be provided with a separate on/off control capable of overriding the setback thermostat if desired.

Unless the elimination of the setback thermostat is factored into the compliance analysis for the following systems, the setback thermostat must be installed *(compliance with a prescriptive package always requires a setback thermostat):*

- Non-central electric heaters
- Room air conditioners
- Room air conditioner heat pumps
- Gravity gas wall heaters
- Gravity floor heaters
- Gravity room heaters
- Room air conditioners

Automatic setback thermostats can add both comfort and convenience to a home. Occupants can wake up to a warm house in the winter and come home to a cool house in the summer without using unnecessary energy.

All heating and/or cooling systems must have an automatic setback thermostat with a clock mechanism that shuts the system off during periods of non-use and that allows the building occupant to automatically set back the thermostat set points for at least two periods within 24 hours. Note that setback thermostats for heat pumps must be “smart thermostats” that minimize the use of supplementary electric resistance heating during startup and recovery from setback, as discussed in the next section

The only exception is if the HVAC system on the CF-1R shows the thermostat type as “non-setback” for a building using computer performance compliance. This exception is not allowed for the alternative component packages because this approach does not

factor into the compliance the lack of setback capabilities. The exception also only applies to non-central systems as identified above.

Check the CF-1R for automatic setback thermostat requirements. A setback thermostat is mandatory for central systems. An exception is allowed if : (1) the building complied using a computer performance approach with a non-setback thermostat; and (2) the system is one of the following non-central types:

- Non-central electric heaters
- Room air conditioners
- Room air conditioner heat pumps
- Gravity gas wall heaters
- Gravity floor heaters
- Gravity room heaters
- Room air conditioners

This exception is not allowed for alternative component packages because this approach does not factor into the compliance the lack of setback capabilities. Setback is typically achieved with a timeclock on the thermostat or with a digital readout.

Example 2-5 – Setback Thermostat Requirement

Question

Am I exempt from the requirement for a setback thermostat if I have a gravity wall heater or any of the equipment types listed in the exception to §150(i)?

Answer

Exemption from the requirement depends on the compliance approach you are using. The exception requires that "the resulting increase in energy use due to the elimination of the setback thermostat shall be factored into the compliance analysis." The only compliance approach that models this condition is the computer performance compliance approach. To be exempt from the setback thermostat requirement, the building/space must be modeled with "non-setback." Any time the alternative component packages are used for compliance, a setback thermostat is required, regardless of the type of heating/cooling system (except wood stoves).

2.5.4 Heat Pump Controls

§112(b)

(b) ***Controls for Heat Pumps with Supplementary Electric Resistance Heaters****. Heat pumps with supplementary electric resistance heaters shall have controls:*

1. *That prevent supplementary heater operation when the heating load can be met by the heat pump alone; and*
2. *In which the cut-on temperature for compression heating is higher than the cut-on temperature for supplementary heating, and the cut-off temperature for compression heating is higher than the cut-off temperature for supplementary heating.*

EXCEPTION to Section 112(b): The controls may allow supplementary heater operation during:

I. Defrost; and

II. Transient periods such as start-ups and following room thermostat setpoint advance, if the controls provide preferential rate control, intelligent recovery,

staging, ramping, or another control mechanism designed to preclude the unnecessary operation of supplementary heating.

Any heat pump with supplementary electric resistance heating must have controls that have two capabilities to limit the electric resistance heating. The first capability of the control is to set the cut-on and cut-off temperatures for compression and supplementary heating at different levels. For example, if the heat pump begins heating when the inside temperature reaches 68 ºF, the electric resistance heating is set to come on if the temperature gets below 65 ºF; and the opposite off mode so that if the heat pump shuts off when the temperature reaches 72 ºF, the back-up heating shuts off at 68ºF.

The second function of the control prevents the supplementary electric resistance heater from operating when the heat pump alone can meet the heating load, except during defrost. There is a limited exception to this second function for "smart thermostats" that provide: intelligent recovery, staging, ramping, or another control mechanism that prevents the unnecessary operation of supplementary electric resistance heating when the heat pump alone can meet the heating load. To meet the setback thermostat requirements discussed in the previous section, a setback thermostat for a heat pump must be a "smart thermostat" that minimizes the use of supplementary heating during startup and recovery from setbacks

With such controls supplementary heater operation is permitted during defrost and transient periods such as start-ups, and following room thermo-stat setpoint advance.

Note: Room air conditioner heat pumps are not required to comply with these requirements.

2.5.5 Insulation for Refrigerant Lines in Split System Air Conditioners

Two refrigerant lines connect the indoor and outdoor units of split system air conditioners and heat pumps: the liquid line and the suction line. The liquid line is at an elevated temperature and it is helpful if heat escapes, therefore, it should generally not be insulated. However, the suction carries refrigerant from the indoor unit back to the outdoor unit and is at a temperature below 55 ºF. The suction line must be insulated with at least R-3 insulation, per the requirements of §150 (j) 2.

Insulation used with the suction line must be protected from physical damage or from UV deterioration. Pipe insulation in outdoor locations is typically protected by aluminum or sheet metal jacket, painted canvas, a plastic cover, or coatings that are water retardant and UV resistant. See §150 (m) 9.

2.5.6 Ducts, Plenums, and Fans

The section focuses on minimum mandatory requirements for duct construction and includes excerpts from the *California Mechanical Code* and construction details from the Air Diffusion Council. Chapter 4 and Appendices J and K contain additional details on construction and diagnostic testing of ducts to eliminate potentially significant energy losses.

A. Standards Language

§150(m)

The following language (in italics) is taken from §150 (m) of the *Standards*.

1. *CMC Compliance. All air distribution system ducts and plenums, including but not limited to mechanical closets, and air handler boxes shall be installed, sealed and insulated to meet the requirement of the 1998 CMC Sections 601, 603, 604 and*

Standard 6-3, incorporated herein by reference. Portions conveying conditioned air shall either be insulated to a minimum installed level of R-4.2 (or any higher level required by CMC Section 604) or be enclosed entirely in conditioned space. Connections of metal ducts and the inner core of flexible ducts shall be mechanically fastened. Openings shall be sealed with mastic, tape, aerosol sealant or other duct closure system that meets the applicable requirements of UL 181, UL 181A or UL 181B. If mastic or tape is used to seal openings greater than 1/4 inch, the combination of mastic and either mesh or tape shall be used.

Building cavities, support platforms for air handlers, and plenums defined or constructed with materials other than sealed sheet metal, duct board or flexible duct shall not be used for conveying conditioned air. Building cavities and support platforms may contain ducts. Ducts installed in cavities and support platforms shall not be compressed to cause reductions in the cross sectional area of the ducts.

2. *Factory-Fabricated Duct Systems.*

   A. *All factory-fabricated duct systems shall comply with UL 181 for ducts and closure systems, including collars, connections and splices.*

   B. *All pressure-sensitive tapes, heat-activated tapes, and mastics used in the manufacture of rigid fiberglass ducts shall comply with UL 181.*

   C. *All pressure-sensitive tapes, mastics used with flexible ducts shall comply with UL 181 or UL 181B.*

   D. *Joints and seams of duct systems and their components shall not be sealed with cloth back rubber adhesive duct tapes unless such tape is used in combination with mastic and drawbands.*

3. *Field-Fabricated Duct Systems.*

   A. *Factory-made rigid fiberglass and flexible ducts for field-fabricated duct systems shall comply with UL 181. All pressure-sensitive tapes, mastics, aerosol sealants or other closure systems used for installing field-fabricated duct systems shall meet the applicable requirements of UL 181, UL 181A or UL 181B. Note: If these requirements do not apply then they are met.*

   B. *Mastic Sealants and Mesh.*

      i. *Sealants shall comply with UL 181, UL 181A, or UL 181B, and be non-toxic and water resistant.*

      ii. *Sealants for interior applications shall pass ASTM tests C 731 (extrudability after aging) and D 2202 (slump test on vertical surfaces), incorporated herein by reference.*

      iii. *Sealants for exterior applications shall pass ASTM tests C 731, C 732 (artificial weathering test) and D 2202, incorporated herein by reference.*

      iv. *Sealants and meshes shall be rated for exterior use.*

   C. *Pressure-Sensitive Tape. Pressure-sensitive tapes shall comply with UL 181, UL 181A, or UL 181B.*

   D. *Joints and seams of duct systems and their components shall not be sealed with cloth back rubber adhesive duct tapes unless such tape is used in combination with mastic and drawbands.*

   E. *Drawbands Used with Flexible Duct.*

      i. *Drawbands shall be either stainless-steel worm-drive hose clamps or uv-resistant nylon duct ties.*

ii. Drawbands shall have a minimum tensile strength rating of 150 pounds.

iii. Drawbands shall be tightened as recommended by the manufacturer with an adjustable tensioning tool.

F. Aerosol-Sealant Closures.

i. Aerosol sealants shall meet the applicable requirements of UL 181, 181A or 181B and be applied according to manufacturer specifications. If the requirements of UL181, UL181A, or UL181B do not apply then these requirements are met.

ii. Tapes or mastics used in combination with aerosol sealing shall meet the requirements of this section.

4. All duct insulation product R-values shall be based on insulation only (excluding air films, vapor barriers, or other duct components) and tested C-values at 75°F mean temperature at the installed thickness, in accordance with ASTM C518-85 or ASTM C177-85, incorporated herein by reference, and certified pursuant to Section 118.

5. The installed thickness of duct insulation used to determine its R-value shall be determined as follows:

A. For duct board, duct liner and factory-made rigid ducts not normally subjected to compression, the nominal insulation thickness shall be used.

B. For duct wrap, installed thickness shall be assumed to be 75 percent (25 percent compression) of nominal thickness.

C. For factory-made flexible air ducts, the installed thickness shall be determined by dividing the difference between the actual outside diameter and nominal inside diameter by 2.

6. Insulated flexible duct products installed to meet this requirement must include labels, in maximum intervals of 3 feet, showing the thermal performance R-value for the duct insulation itself (excluding air films, vapor barriers, or other duct components), based on the tests in Section 150(m)4. and the installed thickness determined by Section 150(m)5.C.

7. All fan systems, regardless of volumetric capacity, that exhaust air from the building to the outside shall be provided with backdraft or automatic dampers to prevent air leakage.

8. All gravity ventilating systems that serve conditioned space shall be provided with either automatic or readily accessible, manually operated dampers in all openings to the outside except combustion inlet and outlet air openings and elevator shaft vents.

9. Protection of Insulation. Insulation shall be protected from damage, including that due to sunlight, moisture, equipment maintenance, and wind but not limited to the following: Insulation exposed to weather shall be suitable for outdoor service; e.g., protected by aluminum, sheet metal, painted canvas, or plastic cover. Cellular foam insulation shall be protected as above or painted with a coating that is water retardant and provides shielding from solar radiation that can cause degradation of the material.

EXCEPTION to Section 150(m)1.: The requirements do not apply to ducts and fans integral to a wood heater or fireplace.

Summary of Requirements from Standards

Insulation and Installation

Each duct system efficiency measure must meet or exceed both the Energy Efficiency Standards and the CMC. Where there are differences between the two standards, the more stringent applies. Ducts conveying conditioned air must either be insulated to a minimum installed level of R-4.2 (or any higher level required by the CMC Section 604) or

be enclosed entirely in conditioned space. All duct insulation R-values shall be based on insulation only (excluding air films, vapor barriers or other duct components) and tested C-factors as specified above in §150(m) 4, and certified pursuant to §118. The installed thickness of duct insulation used to determine its R-value shall be determined in accordance with §150 (m) 5. On and after the effective date designated by the California Building Standards Commission for the 2000 CMC, duct installation, sealing and insulation shall comply with Sections 601, 602, 604, 605 and Standard 6-5 of the 2000 CMC.

In two situations, Section 604 of the CMC requires R-6.3 duct insulation instead of R-4.2. These are:

1. When cooling system ducts are installed on the roof or exterior of the building.
2. When heating system ducts are installed on the roof (exterior) of the building in an area with greater than 8,000 heating degree days (see Appendix C heating degree days (HDD)).

Ducts in Concrete Slab

Ducts located in a concrete slab must also meet the R-4.2 insulation requirements, but for these ducts, there are other issues as well. If ducts are located in the soil beneath the slab or embedded in the slab, the insulation material should be designed and rated for such installation. Insulation installed in below grade applications should resist moisture penetration, e.g. closed cell foam such as extruded polystyrene. Common pre-manufactured duct systems are not suitable for below grade installations. If concrete is to be poured directly over the ducts, then the duct construction and insulation system should be sturdy enough to resist the pressure and not collapse. Insulation should be of a type that will not compress or it should be located inside a rigid duct enclosure. The only time that common flex ducts are suitable in a below grade application is when a channel is provided in the slab.

Notes:

- The insulation levels of the CMC are mandatory *minimum* levels. If compliance calculations show a higher R-value is being used for credit, the higher value is required.
- The duct location must match the location shown on the Certificate of Compliance (CF-1R).

Duct Requirements

These requirements are from both the *Standards* and the CMC.

Additional Duct Construction Requirements

1. Mechanical fastening of connections of metal ducts and the inner core of flexible ducts is required.
2. Openings must be sealed with mastic, tape, aerosol sealant or other duct closure systems that meet the applicable requirements of UL 181.
3. If mastic or tape is used to seal openings greater than 1/4 inch, the combination of mastic and either mesh or tape shall be used.
4. 4. Building spaces such as cavities between walls, support platforms for air handlers, and plenums defined or constructed with materials other than sealed sheet metal, duct board or flexible duct shall not be used for conveying conditioned air including return air and supply air. The practice of using drywall materials as the interior surface of a return plenum is not allowed. Building cavities and support platforms may contain ducts. Ducts installed in cavities and support platforms shall not be compressed to cause reductions in the cross sectional area of the ducts. Although a HERS rater may examine this as a part of their responsibilities when they are involved in a project, the enforcement of these minimum standards for ducts is the responsibility of the building official.

Ducts and fans integral to a wood heater or fireplace are exempt from these insulation and installation requirements.

Factory-Fabricated Duct Systems and Field-Fabricated Duct Systems

Duct systems may not use cloth back, rubber adhesive duct tape unless it is installed in combination with mastic and drawbands. The enforcement of these minimum standards is the responsibility of the building official.

Product Markings

Insulated flexible duct products installed to meet this requirement must include labels, in maximum intervals of three feet, showing the R-value for the duct insulation (excluding air films, vapor barriers or other duct components), based on the tests and thickness specified in §150(m) above.

Fan, Exhaust, and Ventilation

Fan systems that exhaust air from the building to the outside must be provided with back draft or automatic dampers.

Gravity ventilating systems must have an automatic or readily accessible, manually operated damper in all openings to the outside, except combustion inlet and outlet air openings and elevator shaft vents. This includes clothes dryer exhaust when installed in conditioned space.

Protection of Insulation

Insulation shall be protected from damage as described in §150 (m) 9.

Installation

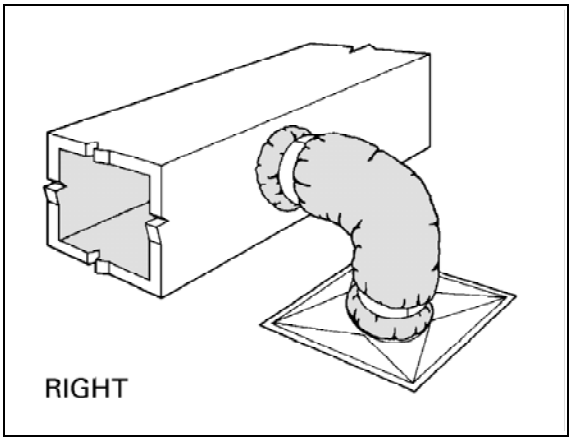
Appendix K also contains a recommended detailed listing for inspecting quality constructed ducts and Section 6.310 of Standard 6-3 of the CMC has an enforcement checklist for flexible duct installations.

2.5.7 Duct Installation Standards

These following standards are derived from the CMC (Section 6-30 are based on the descriptions given in *Flexible Duct Performance and Installation Standards* published by the Air Diffusion Council, 104 South Michigan Avenue, Suite 1500, Chicago, Illinois 60603, telephone (312) 201-0101. They have been modified to be consistent with the requirements of the Energy Efficiency Standards.

Note: These are minimum standards. Duct systems may not use cloth back, rubber adhesive duct tape unless it is installed in combination with mastic and drawbands. Building cavities, support platforms for air handlers, and plenums defined or constructed with materials other than sealed sheet metal, duct board or flexible duct shall not be used for conveying conditioned air including return air and supply air. Building cavities and support platforms may contain ducts. Ducts installed in cavities and support platforms shall not be compressed to cause reductions in the cross sectional area of the ducts. The enforcement of these minimum standards is the responsibility of the building official.

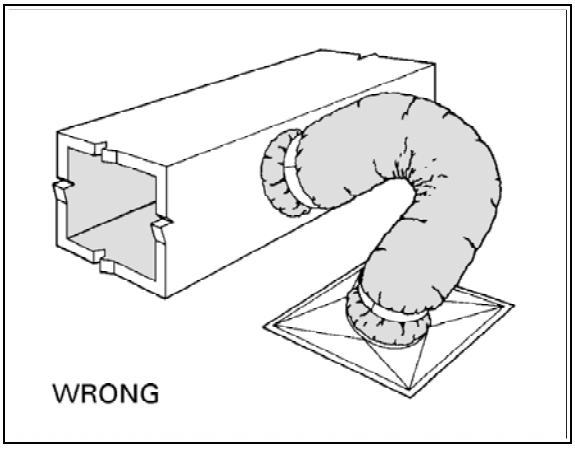
Figure 2-12 – Duct Installation (Right)



Ducts shall be installed fully extended as shown in Figure 2-12. If compressed or with excess lengths, as shown in

Figure 2-13, friction losses are increased.

Figure 2-13 – Duct Installation (Wrong)



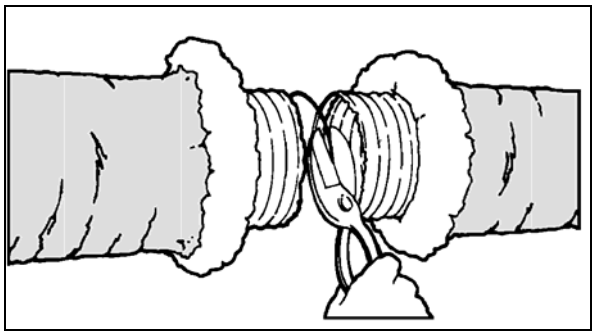
Avoid bending ducts across sharp corners or incidental contact with metal fixtures, pipes or conduits. Also avoid installing the duct near hot equipment such as furnaces, boilers, or steam pipes, which are above the recommended flexible duct use temperature.

Connecting, Joining and Splicing Flexible Duct

All connections, joints and splices shall be made in accordance with the manufacturer's installation instructions. For flexible ducts with plain ends, standardized installation instructions are shown in Figure 2-14A through C for nonmetallic ducts. Because of the variety of ducts and duct assemblies with special end treatments, no standardized installation instructions are shown. Instead, consult the manufacturer's installation instructions. Sheet metal collars to which the flexible ducts with plain ends are attached shall be a minimum of 2 inches in length. Sheet metal sleeves used for joining two sections of flexible ducts with plain ends shall be a minimum of 4 inches in length. Sheet metal collars and sleeves should be beaded for pressures exceeding 2 inches w.g. (500 Pa) and for diameters 12 inches and larger when used with metallic ducts.

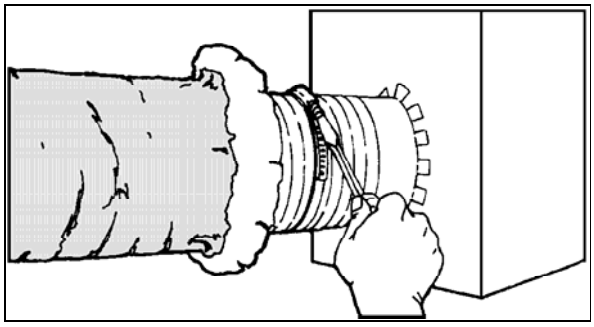
Nonmetallic Air Ducts and Air Connectors

Figure 2-14 A – Connections for Nonmetallic Air Ducts and Air Connectors



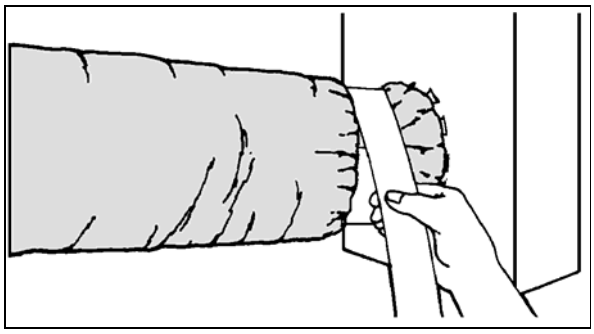
Cut completely around and through duct with knife or scissors. Cut wire with wire cutters.

Figure 2-14 B – Connections for Nonmetallic Air Ducts and Air Connectors



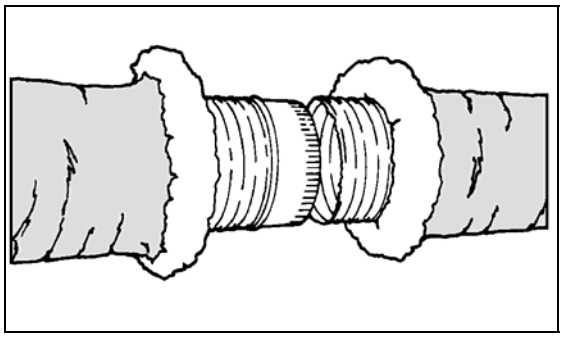
Pull jacket and insulation back from core. Slide at least 1 inch of core over collar, pipe or fitting. Tape core with at least two wraps of tape. Secure with a clamp. Duct systems may not use cloth back, rubber adhesive duct tape unless it is installed in combination with mastic and drawbands. The connector fitting to the plenum shown as a "finger joint" connection in this figure is shown prior to sealing. Mastic should be used for sealing this connection to the plenum.

Figure 2-14 C – Connections for Nonmetallic Air Ducts and Air Connectors



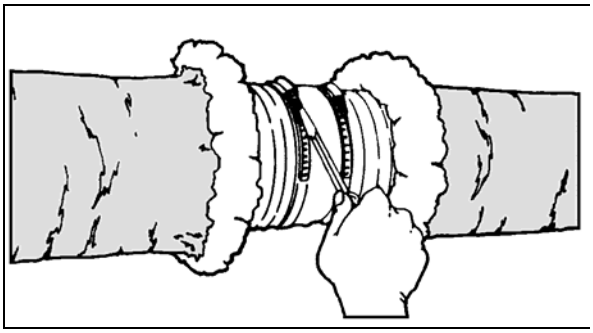
Pull jacket and insulation back over core. Tape jacket with at least two wraps of duct tape. Duct systems may not use cloth back, rubber adhesive duct tape unless it is installed in combination with mastic and drawbands. A clamp must be used in place of or in combination with cloth back rubber adhesive duct tape.

Figure 2-15 A – Splices for Nonmetallic Air Ducts and Air Connectors



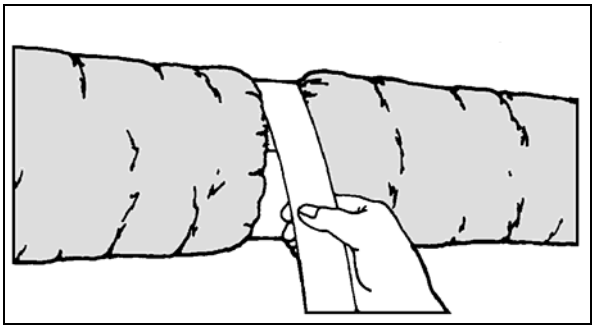
Peel back jacket and insulation from core. Butt two cores together on a standard 4-inch metal sleeve.

Figure 2-15 B – Splices for Nonmetallic Air Ducts and Air Connectors



Tape core with at least two wraps of approved tape. Duct systems may not use cloth back, rubber adhesive duct tape unless it is installed in combination with mastic and drawbands. Secure with two clamps.

Figure 2-15 C – Splices for Nonmetallic Air Ducts and Air Connectors



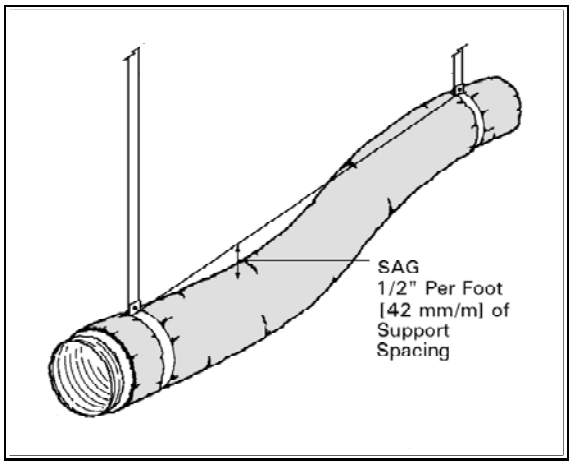
Pull jacket and insulation back over cores. Tape jacket. Tape jacket with at least two wraps of approved tape. Duct systems may not use cloth back, rubber adhesive duct tape unless it is installed in combination with mastic and drawbands.

Notes (for Figures Figure 2-14 and Figure 2-15):

1. Use beaded fittings for pressures exceeding 2 inches w.g. (500 Pa) and for diameters 12 inches and larger.
2. Use tapes listed and labeled to Standard UL 181B and marked 181B-FX.
3. Use clamps as specified on manufacturer's UL 181 installation instructions.

Supporting Flexible Duct

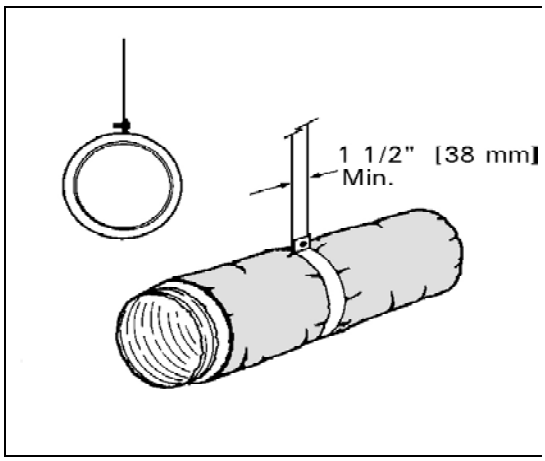
Figure 2-16 – Flexible Duct Support



Flexible duct shall be supported at manufacturers recommended intervals, but no greater than a distance of four feet. Maximum permissible sag is 1/2 inch per foot of space between supports.

A connection to rigid duct or equipment shall be considered a support joint. Long horizontal duct runs with sharp bends shall have additional supports before and after the bend approximately one duct diameter from the centerline of the bend.

Figure 2-17 – Hanger or Saddle Material



Hanger or saddle material in contact with the flexible duct shall be of sufficient width to prevent any restriction of the internal diameter of the duct when the weight of the supported section rests on the hanger or saddle material. In no case will the material in contact with the flexible duct be less than 1-1/2 inches wide.

2.5.8 Pilot Lights

Continuously burning pilot lights are prohibited for fan type central furnaces. For more information see Section 2.6.6.

2.6 Water Heating and Plumbing

This section discusses the mandatory measures for the following topics.

Equipment Certification

Water Heater Tank Insulation

Pipe Insulation

Solar Water Heating

Pool and Spa Equipment

Pilot Lights Prohibited

2.6.1 Equipment Certification

Hot water heaters must be certified by manufacturers as complying with applicable *Appliance Efficiency Regulations* at the time of manufacture. Regulated equipment may not be sold in California unless it is certified. This includes the following types of water heaters and appliances:

- Gas water heaters
- Heat pump water heaters
- Electric storage water heaters
- Oil-fired water heaters
- Shower heads and faucets

These appliances are regulated either by the Appliance Efficiency Regulations or by section 113.

If any equipment does not meet the federal appliance efficiency standards, it may not be sold in California. Any equipment covered by the *Appliance Efficiency Regulations* and sold in California must have the date of manufacture permanently displayed in an accessible place on that equipment. This date is frequently included as part of the serial number.

The person who signs off on the Installation Certificate (CF-6R) is required to certify that the actual equipment installed meets or exceeds the requirements of the *Appliance Efficiency Regulations* and that the equipment is equivalent to, or more efficient than the equipment described on the Certificate of Compliance attached to the plans.

Water Heating

The number and types of water-heater systems installed must correspond to the approved CF-1R. The location of the water heater, adding a recirculating system, and a hot water-recovery system are all factors of the distribution system and play a significant role in water heating compliance. The distribution system must correspond to plan specifications.

The installation criteria for water heating distribution systems are described in Chapter 6, Section 6.6.

Faucets and Shower Heads

Faucets and showerheads are limited by a federal standard to 2.5 gallons per minute. If equipped with a flow restrictor, it must be mechanically retained which means it requires eight pounds or more of pulling force to remove.

Note: A reduced flow rate saves in two ways: (1) water-heating energy makes up about one-quarter of all energy in residences, so less water means less hot water; and (2) a 10 % cut in water use means $100,000 in electricity savings from reduced pumping costs theoretically for one water district.

Water Heating

Check that the number and types of water-heater systems are installed, as indicated on the CF-6R, and check to see that this corresponds to the approved CF-1R. The distribution system is also significant and must correspond to plan specifications. For example:

- If the plans indicate the presence of a hot water recovery system, it must be installed.

- If a recirculation system is installed, verify that it was accounted for in the compliance documentation (CF-1R) and check for any required controls (e.g., demand pump, timer).
- If a point of use credit is specified, the water heater must be no further than eight feet from all hot water outlets (excluding washing machines).

See Section 5.1, for a summary of the different distribution system types and installation requirements for each. Note whether each one is a credit or a penalty as compared with the standard distribution system.

Verify that the make and model number of the installed water-heater unit match those listed on the Installation Certificate (CF-6R).

If a storage gas water heater has an energy factor (EF) of less than 0.58, an R-12 water-heater blanket is required (internal insulation cannot be used to satisfy this mandatory requirement). For water heaters with 0.58 EF or higher or large storage (typically commercial size) water heaters whose rated input is greater than 75,000 Btu/h, that are not rated using an energy factor, no insulation blanket is required. The blanket should be securely attached around the water heater. The top of the water heater should not be insulated and a cutout in the blanket should be provided for combustion air intake.

Faucets and Shower Heads

Faucets and showerheads are limited by a federal standard to 2.5 gallons-per-minute. If equipped with a flow restrictor, it must be mechanically retained which means it requires eight pounds or more of pulling force to remove.

2.6.2 Water Heater Tank Insulation

§150(j)1

A. Storage gas water heaters with an energy factor < 0.58 shall be externally wrapped with insulation having an installed thermal resistance of R-12 or greater.

B. Unfired hot water tanks, such as storage tanks and backup storage tanks for solar water heating systems, shall be externally wrapped with insulation having an installed thermal resistance of R-12 or greater or have internal insulation of at least R-16 and a label on the exterior of the tank showing the insulation R-value.

Insulation is not a factor in the compliance calculations, but is a mandatory requirement for some units. For storage water heaters with an energy factor of less than 0.58, an R-12 insulation wrap is required. Any unfired tanks (used as a back-up for solar water heating or as storage for a boiler) must either be insulated externally with R-12 or have a label indicating the tank is internally insulated with R-16.

Storage water heaters with an efficiency of less than 0.58 energy factor must be wrapped with an R-12 insulation blanket. Internal insulation cannot be substituted for this insulation. Large storage water heaters with a rated input greater than 75,000 Btu/h that are not rated with an energy factor (EF) are not required to have an external R-12 insulation blanket.

Unfired tanks used as a back-up for solar water heating, or as storage for a boiler, must either be insulated externally with R-12 or have a label indicating that the tank is internally insulated with R-16. Alternatively, proof that the heat loss of the tank surface, based on an 80ºF water-air temperature difference, is less than 6.5 Btu/hr-ft^2.

In most common situations a water heater blanket is not required. There are only two cases where an R-12 wrap is required:

- *Storage* water heater with an energy factor of less than 0.58.
- *Unfired* water heater without a label specifying R-16 internal insulation.

2.6.3 Pipe Insulation

§150(j)2

Piping, whether buried or unburied, for recirculating sections of domestic hot water systems, piping from the heating source to the storage tank for an indirect-fired domestic water heating system, cooling system piping below 55 degrees Fahrenheit, and the first five feet of hot and cold water pipes from the storage tank for non-recirculating systems shall be thermally insulated in accordance with Table No. 1-T [Table 2-6 below].

EXCEPTIONS to Section 150(j)2.: The following piping does not have to be thermally insulated: (1) factory-installed piping within space conditioning equipment; and (2) piping that conveys fluids that have a design operating temperature range between 55 degrees and 105 degrees Fahrenheit.

NOTE to Section 150(j)2.: Where the Executive Director approves a water heater calculation method for a particular water heating recirculation system, piping insulation requirements shall be those specified in the approved calculation method.

Table 2-6 – Pipe Insulation Requirements Minimum R-value – Table 1-T from §150(j)2.

System	Pipe Diameter	
	Less than or equal to 2"	Greater than 2"
Domestic Hot Water	R-4	R-6
Hydronic Heating Supply Lines	R-4	R-6
Cooling Systems (pipes below 55°F)	R-3	R-4

The suction line from the indoor unit to the outdoor unit in split system air conditioners and heat pumps must be insulated with a minimum of R-3 insulation, since this line carries a fluid at a temperature below 55 ºF.

The following piping must be insulated in accordance with Table 2-6 above:

- Storage tanks for a non-recirculating system must have pipe insulation on both hot and cold water pipes for a length of five feet. There is no exception for water heater piping in the conditioned space.
- Insulate the cold water pipe close to the storage tank since the cold water pipe draws heat from the tank and loses some of that heat convectively to the air.
- Recirculating sections of domestic hot water systems (the entire length of piping, whether buried or exposed).
- Indirect fired domestic hot water system piping from the heating source to the storage tank.
- Cooling system piping below 55 ºF.

Other installation information:

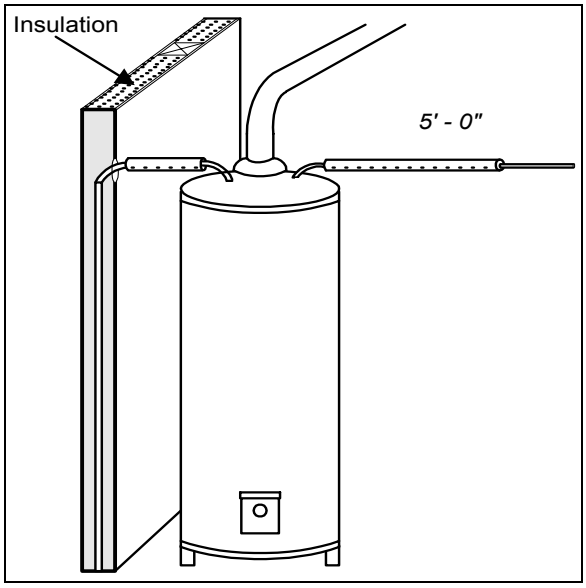
- No insulation should be installed closer than six inches from the flue. If possible bend the pipe away from the flue, otherwise, it may be necessary to stop pipe insulation short of the storage tank (see *1997 California Mechanical Code*, Section 304, Table 3-C).
- All pipe insulation seams should be sealed.

- Installed piping should not be located in supply or return air plenums.
- Hot and cold water piping, when installed in parallel runs should be a minimum of six inches apart.
- If the pipe is interrupted by a wall, the wall insulation can, if it surrounds the pipe as shown in Figure 2-18, be used to meet the mandatory requirements in place of pipe insulation. The full five feet must be insulated.
- If a firewall interrupts the first five feet of pipe, the insulation may be interrupted at the wall and continued on the other side.

Piping *exempt* from this insulation requirement includes:

- Factory installed piping within space conditioning equipment; and
- Piping that conveys fluids that have a design operating temperature range between 55ºF and 105ºF.

Figure 2-18 – Meeting Pipe Insulation Requirements for Storage Tank Water Heaters



The following insulation is required (insulation values are for two inches or less pipes):

- R-4 on the first five feet of hot and cold water pipes for storage, non-recirculating system. There is no exception for water heater piping in the conditioned space.
- R-4 on the entire length of hot water recirculating piping on a recirculating system, regardless of the location of the piping.
- R-4 on piping from the heating source to the storage tank for boilers or solar water heating;
- R-3 on cooling system piping below 55ºF; and,
- Other insulation shown on the CF-1R that is being used for a credit and must be installed as indicated on the plans.

Example 2-6 – Water Heater Pipe Insulation

Question

I thought I was supposed to insulate the water heater pipes for either the first five feet or the length of piping before coming to a wall, whichever is greater. Did I misunderstand?

Answer

Yes. The requirement is that you must insulate the entire length of the first five feet, regardless of whether there is a wall (*Standards*, §150(j)2). You have two options: (1) interrupt insulation for a fire wall and continue it on the other side of the wall, or (2) run the pipe through an insulated wall, making sure that the wall insulation completely surrounds the pipe.

Question

When insulating the water heater piping, do I need to put insulation on the first five feet of cold water pipe?

Answer

Yes. §150(j)2 requires insulation on the cold water pipe also. When heated, the water expands and pushes hot water out the cold water line. This can start thermosyphoning, which continues to remove heat from the stored water. The insulation helps reduce this effect.

Question

If the energy calculations show R-4 pipe insulation, is this a credit? What are the installation requirements for obtaining credit?

Answer

If R-4 pipe insulation is indicated on any form other than the MF-1R it is being used to obtain credit. (The MF-1R form indicates only mandatory insulation requirements—the first five feet of piping for a non-recirculating system or the entire length of recirculating sections of hot water piping for a circulating system.) If R-4 is indicated on the Computer Summary (C-2R) or the Certificate of Compliance (CF-1R) it is being calculated as a credit.

The installation requirements for receiving the R- 4 piping insulation credit are:

A non-recirculating water-heating system

R-4 (or greater) insulation

Insulation applied to all 3/4 inch or larger hot water mains

Neither attic, wall, nor underfloor insulation can be used as a substitute for this insulation.

These requirements are in addition to mandatory insulation requirements of §150(j).

Question

Can I get pipe insulation credit for a recirculating water-heating system?

Answer

No. Recirculating water-heating systems have a mandatory insulation requirement for the recirculating sections of hot water pipes. Pipes less than 2 inches must be insulated to R-4 and pipes greater than 2 inches need R-6 insulation.

Question

When I'm insulating the pipes for a recirculating water-heating system, I insulate the entire length of hot water pipes. Do I need to insulate the runouts?

Answer

No. Since the water in runouts does not recirculate, they do not need to be insulated.

2.6.4 Solar Water Heating

§150(j)3

Solar water heating systems and/or collectors shall be certified by the Solar Rating and Certification Corporation.

Solar water-heating systems and/or collectors must be certified by the Solar Rating and Certification Corporation (SRCC).

- Certification of solar system and/or collectors by the Solar Rating and Certification Corporation (SRCC)
- Piping insulation from the indirect fired hot water system to the heat source
- Tank insulation on an indirect fired water heater without a label specifying R-16 internal insulation.

2.6.5 Pool and Spa Equipment

§114

Mandatory Requirements for Pool and Spa Heating Systems and Equipment.

(a) Certification by Manufacturers. Any pool or spa heating system or equipment may be installed only if the manufacturer has certified that the system or equipment has all of the following:

1. Efficiency. A thermal efficiency for gas-fired systems of at least 78%, when tested according to ANSI Standard Z21.56-1994; and

2. On-Off Switch. A readily accessible on-off switch, mounted on the outside of the heater, that allows shutting off the heater without adjusting the thermostat setting; and

3. Instructions. A permanent, easily readable, and weatherproof plate or card that gives instruction for the energy efficient operation of the pool or spa and for the proper care of pool or spa water when a cover is used; and

4. Electric Resistance Heating. No electric resistance heating; and

EXCEPTION No. 1 to Section 114(a)4.: Listed package units with fully insulated enclosures, and with tight-fitting covers that are insulated to at least R-6.

EXCEPTION No. 2 to Section 114(a)4.: Pools or spas deriving at least 60% of the annual heating energy from site solar energy or recovered energy.

5. Pilot Light. No pilot light.

(b) Installation. Any pool or spa heating system or equipment shall be installed with all of the following:

1. Piping. At least 36" of pipe between the filter and the heater, to allow for the future addition of solar heating equipment; and

2. Covers. A cover for outdoor pools or outdoor spas; and

EXCEPTION to Section 114(b)2.: Pools or spas deriving at least 60% of the annual heating energy from site solar energy or recovered energy.

3. Directional Inlets and Time Switches for Pools. If the system or equipment is for a pool:

A. The pool shall have directional inlets that adequately mix the pool water; and

B. The circulation pump shall have a time switch that allows the pump to be set to run in the off-peak electric demand period, and for the minimum time necessary to maintain the water in the condition required by applicable public health standards.

EXCEPTION to Section 114(b)3.B.: Where applicable public health standards require on-peak operation.

Before any pool or spa heating system or equipment may be installed, the manufacturer must certify to the Commission that the system or equipment complies with §114. The requirements include minimum heating efficiency, an on-off switch, permanent operating instructions, no pilot light, and no electric resistance heating. There are two exceptions for electric heaters- they may be installed for:

- Listed package units with fully insulated enclosures (e.g., hot tubs), and with tight-fitting covers, insulated to at least R-6.
- Pools or spas getting 60% or more of their annual heating from site solar energy or recovered energy.

Any pool or spa must be installed with all of the following:

- At least 36 inches of pipe between the filter and heater to allow for the future addition of solar heating equipment;
- A cover for outdoor pools or outdoor spas except for pools or spas deriving at least 60% of the annual heating energy from site solar energy or recovered energy;
- If the heating system or equipment is for a pool:
  a. The pool must have directional inlets to adequately mix the pool water; and
  b. The circulation pump must be capable of being set to run for the minimum number of hours to maintain the water in an acceptable condition and to run at off-peak electric demand periods.

Equipment

Gas:

1. Thermal efficiency 78%,
2. Accessible shut-off switch (independent of temperature),
3. Permanent and readable instructions for efficient operation and maintenance, and
4. No pilot light.

Electric:

1. NOT ALLOWED except when:
2. At least 60% solar heating or site recovered energy provided, and
3. Package unit has fully insulated enclosure with tight-fitting, R-6 cover (e.g., hot tub).

Installation

- At least 36-inch pipe length between filter/ heater (for future solar),
- Cover (except if solar heating),
- Ability to mix pool water, and
- Time switch for pool pump (allows control of length of time and time of day)

2.6.6 Pilot Lights Prohibited

This mandatory measure applies to HVAC equipment as well.

§115

Natural Gas Central Furnaces, Cooking Equipment, and Pool and Spa Heaters: Pilot Lights Prohibited.

Any natural gas system or equipment listed below may be installed only if it does not have a continuously burning pilot light:

(a) Fan type central furnaces.

(b) Household cooking appliances.

EXCEPTION to Section 115(b): Household cooking appliances without an electrical supply voltage connection and in which each pilot consumes less than 150 Btu/hr.

(c) Pool heaters.

(d) Spa heaters.

Any of the following natural gas systems or equipment may be installed only if it does *not* have a continuously burning pilot light:

- Fan type central furnaces
- Household cooking appliances, except cook-ing appliances without an electrical supply voltage connection and in which each pilot consumes less than 150 Btu/hr
- Pool heaters
- Spa heaters
- Fireplace*
- Decorative gas appliance*
- Gas log*

*§150(e) specifies that a fireplace, decorative gas appliance, or gas log cannot have a continuously burning pilot light.

The following natural gas appliances cannot have a standing or continuously burning pilot light:

- Fan type central furnaces
- Household cooking appliances, except cook-ing appliances without an electrical supply voltage connection and in which each pilot consumes less than 150 Btu/hr
- Pool heaters
- Spa heaters
- Fireplace
- Decorative gas appliance
- Gas log

Example 2-7 – Continuously Burning Pilot Light

Question

Under what circumstances is a constantly (or continuously) burning pilot light prohibited on certain appliances?

Answer

For compliance with the *Standards*, §115 prohibits continuously burning pilot lights for some natural gas burning equipment (this does not include liquefied petroleum gas burning appliances). §115 prohibits continuous pilots on the following types of equipment:

- Household cooking appliances with an electrical supply voltage connection in which each pilot consumes 150 Btu/hr or more
- Pool heaters
- Spa heaters
- Fan type central furnaces

§150 (e) prohibits continuously burning pilot lights for:

- Fireplaces
- Decorative gas appliances
- Gas logs

For compliance with federal and state appliance regulations (which apply to any appliance sold or offered for sale in California), a constant burning pilot light is prohibited on:

- Gas kitchen ranges and ovens with an electric supply cord
- Pool heaters, except those that burn liquefied petroleum gas

2.7 Lighting

The *Standards* have mandatory measures that address:

- Kitchen Lighting
- Bathroom Lighting
- Recessed Lighting

2.7.1 Kitchen Lighting

§150 (k) 1, 3

1. *Luminaires for general lighting in kitchens shall have lamps with an efficacy of not less than 40 lumens per watt. General lighting must provide a sufficient light level for basic kitchen tasks and provide a uniform pattern of illumination. A luminaire(s) that is (are) the only lighting in a kitchen will be considered general lighting. General lighting shall be controlled by a switch on a readily accessible lighting control panel at an entrance to the kitchen.*

   Additional luminaires to be used only for specific decorative effects need not meet this requirement.

4. *Luminaires installed to meet the 40 lumens per watt requirements of Section 150(k) 1. or 2. shall not contain medium base incandescent lamp sockets, and shall be on separate switches from any incandescent lighting.*

Installing energy-efficient lamps and fixtures can reduce lighting energy costs without sacrificing the quality or quantity of light available. The intent of the kitchen lighting code is not to increase the number of light fixtures and/or watts used by the occupant but rather to ensure that the builder provides - and the occupant uses - energy efficient lighting. As indicated in Table 2-7, a 40-watt (Full-Size, 4' long) standard fluorescent lamp

is over four times as efficient (in terms of efficacy) as a 100-watt standard incandescent lamp ('efficacy' is defined in §101(b) of the *Standards* as, "…the ratio of light from a lamp to the electrical power consumed (including ballast losses) expressed in lumens per watt").

General lighting is the lighting that the occupant will typically use on a regular basis (normally fluorescent lighting, but may be other types with efficacy of 40 lumens per watt or greater). If there is only one light in the kitchen, it is general lighting. The International Society of Illuminating Engineers (IES) guidelines recommend that at least 30 footcandles of light be provided for visual tasks in kitchens. Visual tasks include, but are not limited to, basic kitchen tasks such as preparing meals and washing dishes. These tasks typically occur on accessible kitchen countertops, the tops of ranges and in sinks, where food preparation, recipe reading, cooking, cleaning and related meal preparation activities take place, as well as at the front of kitchen cabinets.

The general lighting in kitchens must:

- Have an efficacy of *at least 40 lumens/watt* (see Table 2-7).
- Provide a uniform pattern of lighting, such as a fixture in the center of the kitchen or around the perimeter (not a fixture in the corner).
- Provide a light level sufficient for performing basic kitchen tasks such as preparing meals and washing dishes.
- Be controlled on a readily accessible switch at an entrance to the kitchen (not in a cupboard or beside the kitchen sink).
- Be switched independent of incandescent lighting.
- Not contain medium-base incandescent lamp sockets. This prevents the occupant from replacing the efficient light source with an incandescent lamp.

Additional luminaires for decorative effect do not need to meet these requirements, however, incandescent lighting fixtures recessed into insulated ceilings must be approved for zero-clearance insulation cover (IC-rated) in compliance with §150(k)4 (see Recessed Lighting below).

To clearly demonstrate compliance with the *Standards* to a building department, a lighting layout design that includes a point-by-point illuminance grid for the high-efficacy lighting may be provided. To do this properly, this grid must account for the room geometry, fixture placement, photometric data for the fixtures, lamp lumens, lamp lumen depreciation, and reflectivity of all of the surfaces in the kitchen.

Table 2-7 – Typical Efficacy of Electric Lighting Sources

Light Source	Type	Rated Lamp (Watts)	Typical Efficacy (Lumens / Watt)[1]
Incandescent	Standard	40 - 100	14 - 18
Incandescent	Halogen	40 - 250	20[2]
Incandescent	Halogen IR	See footnote [3]	Up to 30
Fluorescent (Lamp/ Ballast Systems)[4]	Full-Size, 4' Long	32 - 40	69 - 91
	U-Shaped T-8 Bipin	16 - 31	78 - 90
	Compact Fluorescent	5 - 9	26 - 38
	Compact Fluorescent	13 +	42 - 58
Metal Halide	Metal Halide	32 - 175	50 - 90
High Pressure Sodium	White High Pressure Sodium	35 - 100	36 - 55

1 Includes power consumed by ballasts where applicable.

2 Halogen capsule incandescent lamps may be the most efficient light source for highlighting applications. Most halogen lamps are designed to produce a beam of directed light. Manufacturer's data typically list the "candlepower" intensity of that beam, rather than lumens (lumens measure total light output in all directions).

3 A new technology using infrared reflecting films on the halogen capsules has increased output up to 30 lumens/watt for some high wattage lamps.

4 Efficacy of fluorescent lighting varies depending on lamp and ballast types.

Example 2-8 – Energy-efficient Kitchen Lighting, General

Question

I want to design and provide an energy efficient kitchen. I especially want the lighting design to provide an aesthetically pleasing appearance, sufficient light for basic kitchen tasks, and be energy efficient while also complying with the Energy Efficiency Standards. What is the recommended practice for achieving this goal?

Answer

It is recommended that the builder use one of the following four ways to show compliance:

1. Design and install only high-efficacy luminaires in the kitchen. This scenario meets the code requirement in the most straightforward manner. When kitchen lighting includes both high-efficacy sources and low-efficacy sources, the design may not meet these requirements. The second through fourth ways of showing compliance apply to kitchens with both high- and low-efficacy sources.
2. Provide at least 1.2 Watts per square foot (total square feet of the accessible kitchen floor and countertop areas) of light from high-efficacy sources, and ensure that, in the judgment of the building department plan checker, the lamps in those fixtures produce a substantially uniform pattern of lighting on kitchen work surfaces (please note that this is not a code requirement but a recommendation).
3. Make sure that at least 50% of the kitchen lighting wattage is high-efficacy, and that, in the judgment of the building department plan checker, the lamps in those fixtures produce a substantially uniform pattern of lighting on kitchen work surfaces (please note that this is not a code requirement but a recommendation).
4. If you wish to be certain you have provided an “energy efficient kitchen…an aesthetically pleasing appearance…sufficient light for basic kitchen tasks…while also complying with the Energy Efficiency Standards,” it is recommended that you use the same procedures used by professional lighting designers (again, the intent of this recommendation is not that these procedures become a standard part of builder submittals, but rather that they are used to provide the best possible solutions for builders who wish to provide high quality lighting designs).

These procedures account for the characteristics of the room and the design and location of the specific high-efficacy luminaires that will be installed as the best method to determine if there is both sufficient and uniform light. A recognized lighting authority, the Illuminating Engineers Society (IES), provides guidelines for good lighting design in their Lighting Handbook, Reference & Application, 10th Edition.

IES guidelines recommend that at least 30 footcandles of light be provided for seeing tasks in kitchens. Visual tasks include, but are not limited to, the basic kitchen tasks that are described in the Energy Commission's *Residential Manual* as preparing meals and washing dishes. These tasks typically occur on accessible kitchen countertops, the tops of ranges and in sinks, where food preparation, recipe reading, cooking, cleaning and related meal preparation activities take place, as well as at the front of kitchen cabinets so that the contents of the cabinet are discernable.

To clearly demonstrate compliance with the *Standards* to a building department, the builder may provide a lighting layout design that includes a point-by-point illuminance grid for the high-efficacy lighting. To do this properly, this grid must account for the room geometry, fixture placement, coefficient of utilization (CU) of the fixtures, lamp lumens, lamp lumen depreciation, and reflectivity of all of the surfaces in the kitchen.

Uniform lighting assures that the minimum amount of light is available on all the work surfaces used in meal preparation and cleanup. Although the design should achieve 30 footcandles on most counter-height, horizontal work surfaces, there may be a few work-surfaces where the lighting levels fall below this value and the fronts of kitchen cabinets may also be below this value. Even in these locations, the lighting level provided by the high-efficacy source should not fall below the IES-recommended lower value for non-critical seeing tasks of 20 footcandles. Parts of counters that are not work surfaces, such as a corner underneath a cabinet, may have a lighting level below 20 footcandles and still meet the requirements of the standard, because meal preparation is unlikely to occur in those areas.

Manufacturers and lighting fixture representatives can often provide such a grid for a specified design. Electrical engineers who do lighting designs and professional lighting designers also often provide designs with a point-by-point illuminance grid.

The plans should identify the type of luminaire and maximum Underwriters Laboratory (UL)-rated lamp watts for each luminaire and should include dimensions and tolerances of each luminaire so that the installer, plan checker, and field inspector can all determine when the lighting installation matches the plan checker's judgment. When calculating the kitchen lighting wattage, the builder should be certain to use the maximum UL-rated wattage for each fixture.

2.7.2 Bathroom Lighting


§150(k)2 - 3

2. *Each room containing a shower or bathtub shall have at least one luminaire with lamp(s) with an efficacy of 40 lumens per watt or greater. If there is more than one luminaire in the room, the high efficacy luminaire shall be switched at an entrance to the room.*

   ALTERNATIVE to Section 150(k)2.: A high efficacy luminaire need not be installed in a bathroom if:

   A. *A luminaire with lamps with an efficacy of 40 lumens per watt or greater is installed in a utility room, laundry room, or garage; and*

B. All luminaires permanently mounted to the residence providing outdoor lighting shall be installed with the following characteristics:

(1) Luminaires with lamps with 40 lumens per watt or greater; or

(2) Luminaires with lamps with an efficacy of less than 40 lumens per watt shall be equipped with a motion sensor.

***Note:** When using this alternative for multiple bathrooms, after complying with B. for the first bathroom, each additional bathroom in which a high efficacy luminaire is not installed must comply with A. alone.*

3. Luminaires installed to meet the 40 lumens per watt requirements of Section 150(k) 1. or 2. shall not contain medium base incandescent lamp sockets, and shall be on separate switches from any incandescent lighting.

Each room with a shower or bathtub must have at least one luminaire with lamps with an efficacy of at least 40 lumens/watt. If there is more than one luminaire in the room, the high-efficacy luminaire must be switched at an entrance to the room.

As an alternative, both of the following are required:

1. A luminaire with 40 lumens/watt lamps must be installed in another room with utilitarian functions such as a laundry room, utility room or garage; and

2. All permanently mounted outside lighting must either be at least 40 lumens/watt or equipped with a motion sensor.

When using this alternative for two or more rooms with showers or bathtubs, compliance with item 1 (above) is sufficient for the second or third rooms since the outside lighting is already in compliance with item 2 above.

Luminaires installed to meet the 40 lumens/watt requirements cannot contain medium base incandescent lamp sockets, and must be on separate switches from incandescent lighting.

Incandescent lighting fixtures recessed into insulated ceilings must be approved for zero-clearance insulation cover (IC-rated) in compliance with §150(k)4 (see below).

Installing energy-efficient lamps and fixtures can reduce lighting energy costs without sacrificing the quality or quantity of light available. As indicated in Table 2-2, a 40 watt standard fluorescent lamp is over four times as efficient as a 100 watt standard incandescent lamp.

Incandescent lighting fixtures recessed into insulated ceilings must be IC-rated in compliance with §150(k)4 (see Example 2-9).

2.7.3 Recessed Lighting

§150(k)4

All incandescent lighting fixtures recessed into insulated ceilings shall be approved for zero-clearance insulation cover (I.C.) by Underwriters Laboratories or other testing/rating laboratories recognized by the International Conference of Building Officials.

All incandescent lighting fixtures recessed into insulated ceilings must be approved for zero-clearance insulation cover (IC-rated) in compliance with §150(k)4. Although this requirement does not apply to fluorescent fixtures, recessed lighting fixtures left un-insulated significantly increase the heat loss through the roof/ceiling area reducing the effectiveness of the insulation. Heat lamps are not required to be IC-rated.

Example 2-9 – Non-IC Rated Incandescent Fixtures

Question

I'd like to know if it is possible to use non-IC rated incandescent fixtures recessed in an insulated ceiling. Although I've never been able to find a bulb heater (heat lamp) that is IC- rated [approved for insulation cover], they are very popular with my customers. Can I use this product?

Answer

It is possible to build a box of gypsum board or other acceptable interior ceiling finishing material over the fixture so that it is below the boundary of the insulated ceiling. By separating the fixture from being recessed into the insulated ceiling it does not need an IC rating. As long as there is sufficient clearance between the fixture and the interior finishing material to prevent a fire hazard, this assembly is acceptable (recessed fluorescent fixtures do not need to be IC-rated). You can build a box like this to install a non-IC heat lamp or other non-IC rated fixtures.

Question

If insulation is installed between floors of an apartment building (sound-proofing), can I install incandescent fixtures that are not IC-rated?

Answer

No. Although this isn't part of the building envelope, *Standards* §150(k) states that any incandescent fixtures recessed into an insulated ceiling must be approved for zero-clearance insulation cover.

2.8 Compliance Documentation

The Mandatory Measures Checklist (see MF-1R form in Appendix A) is used to show compliance with mandatory measures at the documentation stage. The Installation Certificate and insulation Certificate (see the CF-6R and IC-1 forms in Appendix A) are used to demonstrate compliance at the construction phase. Both of these forms must be made available to the inspector during appropriate inspections, and copies must be provided to the original occupants of the building.

Mandatory Measures Checklist. A sample of the recommended Mandatory Measures Checklist (MF-1R) is included here. More information about the form is included in Chapter 1. Blank forms are contained in Appendix A.

Installation Certificate. A sample of the recommended Installation Certificate (CF-6R) is included here. More information about filling out the form or inspections tied to the form are included in Chapter 1. Blank forms are contained in Appendix A.

Insulation Certificate. A sample of the recommended Insulation Certificate (IC-1) is included here. More information about filling out the form or inspections tied to the form are included in Chapter 1. Blank forms are contained in Appendix A.